THE American JOURNAL OF Surgery

APRIL 1955

THURSTON SCOTT WELTON, M.D., EDITOR

Papers of
The American Association
for the
Surgery of Trauma

SIXTY-FOURTH YEAR OF PUBLICATION

APRIL 1955

THE American JOURNAL OF Surgery

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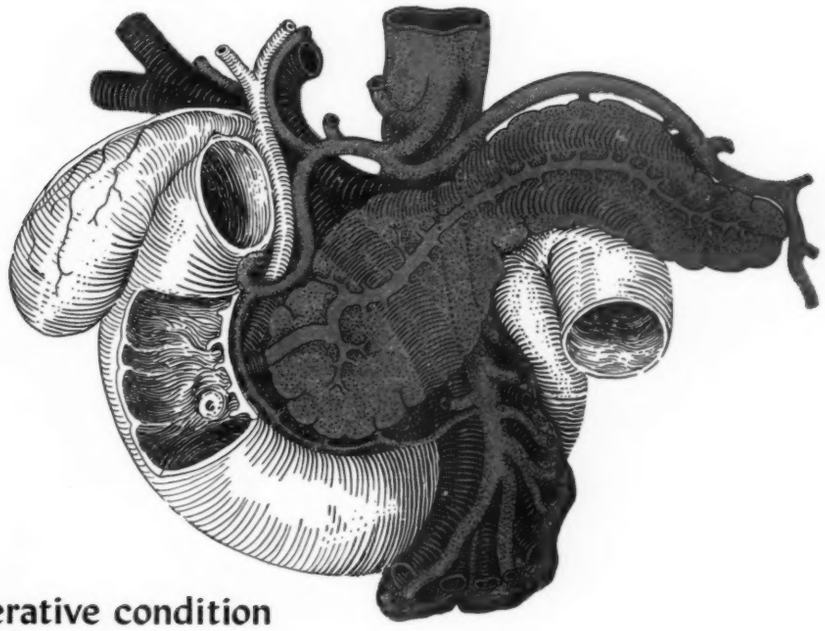

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(1) Schwimmer, D.; Boyd, L. J., and Rubin, S. H.: Bull. New York M. Coll. *16*:102, 1953. (2) Rosser, J. H., and McCall, R. A.: U. S. Armed Forces M. J. *5*:658, 1954. (3) Lichtman, S. S.: Diseases of the Liver, Gallbladder and Bile Ducts, ed. 3, Philadelphia, Lea & Febiger, 1953, vol. 2, pp. 1150, 1229, 1302. (4) Berk, J. E., in Portis, S. A.: Diseases of the Digestive System, ed. 3, Philadelphia, Lea & Febiger, 1953, pp. 573, 580. (5) Best, R. R.; Rasmussen, J. A., and Wilson, C. E.: A.M.A. Arch. Surg. *67*:839, 1953. (6) Behrend, A., and Steppacher, L. G.: Am. J. Surg. *87*:520, 1954.

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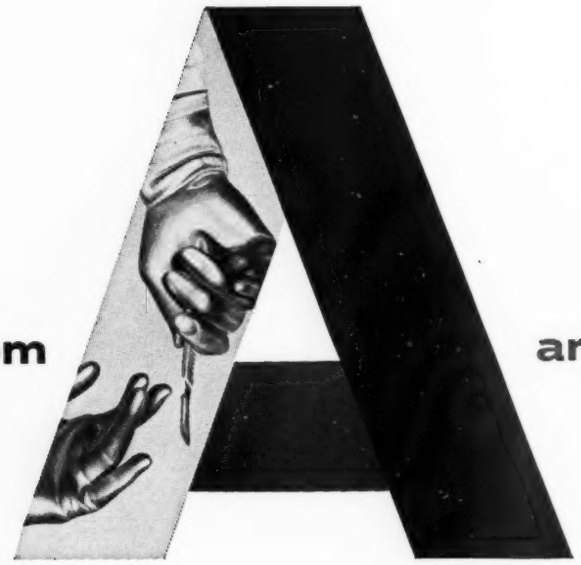
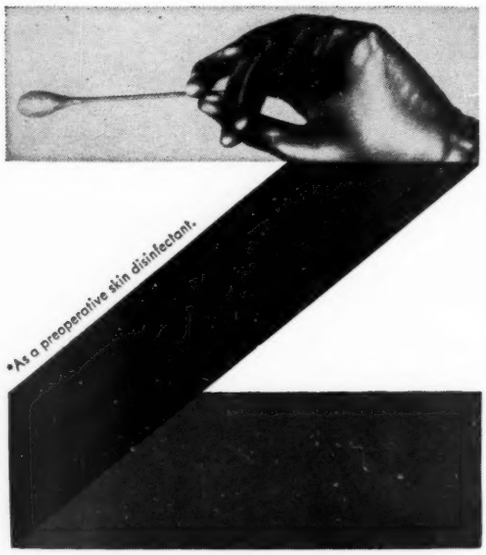
from  amputation



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MANUSCRIPTS: All manuscripts should be addressed to the Editorial Office of the Journal, 49 West 45th Street, New York 36, N. Y.

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ALBUMIN THERAPY IN SHOCK

"...Serum albumin is effective in restoring lost blood volume in cases of experimental and clinical shock and behaves predictably in terms of its known osmotic and other physiochemical properties. In view of the safety, convenience and value of serum albumin as an emergency replacement fluid, in instances of severe injury or blood loss, I hope the day will come when every practicing physician will be able to carry one or two packages in his bag. The fact that the patient receiving serum albumin is safe from the risk of homologous serum hepatitis recommends it particularly as the emergency transfusion fluid of choice."

Janeway, C. A., "Clinical Status of Plasma Fractions," Int'l. Record of Med./Quarterly Rev. of Med., 168:153 (Aug. 1952).

ALBUMIN THERAPY IN CIRRHOSIS

"Intravenous use of salt-poor human albumin is no substitute for nutritional and other recognized therapeutic measures for cirrhosis of the liver. However, when judiciously used in conjunction with other treatment, it may prove to be a valuable adjuvant in the therapy of decompensated hepatic cirrhosis with ascites and edema. In selected instances it may be of crucial benefit in enabling a patient to survive a critical period..."

Portis, S. A., "Treatment of Liver Disease," Med. Clin. of No. Am., 37:1139 (1953).

ALBUMIN THERAPY IN CEREBRAL EDEMA

"...After a period of anoxia, cerebral edema often appears, for which intravenous human serum albumin seems to be an agent of choice.

"Cardiac arrest occurred during spinal anesthesia in a twenty-one year old man undergoing hernioplasty ...Cerebral (and pulmonary) edema followed... Human serum albumin was administered intravenously three times. Recovery was complete within three weeks."

Cole, Frank, "Use of Human Serum Albumin in Cerebral Edema Following Cardiac Arrest," J.A.M.A. 147:1563, (1951).

ALBUMIN THERAPY IN BURNS

"Evidence available at this time suggests that better therapeutic results might be secured if, in addition to whole blood, burn patients requiring blood replacement therapy were to be transfused with purified human serum albumin or a blood substitute suitable for albumin replacement.

"If albumin were to be administered to the system in a relatively pure form (purified normal serum albumin), it would be expected that stress on the liver would diminish and thereby reduce the fibrinogen level, with resultant improvement in the patient's condition..."

Pendergast, J. J., et al, "Albumin and Globulin Changes in Burns as Demonstrated by Electrophoresis," A.M.A. Arch. of Surg. 64:733 (1952).

ALBUMIN THERAPY IN NEPHROTIC SYNDROME

Of all types of edema none is so stubborn or so unpredictable as that associated with the chronic stages of renal disease. There is little doubt that reduced colloid osmotic pressure is an important factor in the production of this form of edema and hence albumin would appear to be the obvious physiological diuretic agent. In patients with the nephrotic syndrome, concentrated, salt-poor albumin has been successfully employed to produce diuresis.

Barness, L. A., Moll, G. H., and Janeway, C. A., "Nephrotic Syndrome," Pediatrics, 5:486 (1950).

ALBUMIN THERAPY IN HYPOPROTEINEMIA

In hypoproteinemic edema, concentrated low-salt albumin provides exactly that combination of properties needed for rational therapy. It is important to relieve edmea promptly in order to promote healing or to relieve symptoms which may be the result of hypoproteinemia.

In studies of patients with acute but reversible hypoproteinemia, the administration of albumin has elevated the level of serum albumin rapidly with diuresis even during periods of increased catabolism, when intravenous amino acids produced little benefit.[1,2]

In another study Schroeder states, "In hypoproteinemia there is excessive readsorption of salt and water by the renal tubules, leading to edema...raising plasma oncotic pressure by the intravenous injection of salt-free albumin will result in diuresis of water..."[3]

1. Janeway, C. A. Ann. Internal Med. 26:368 (1947).
2. Janeway, C. A., J.A.M.A. 126:674 (1944).
3. Schroeder, H. A., J.A.M.A., 147:1109 (1951).

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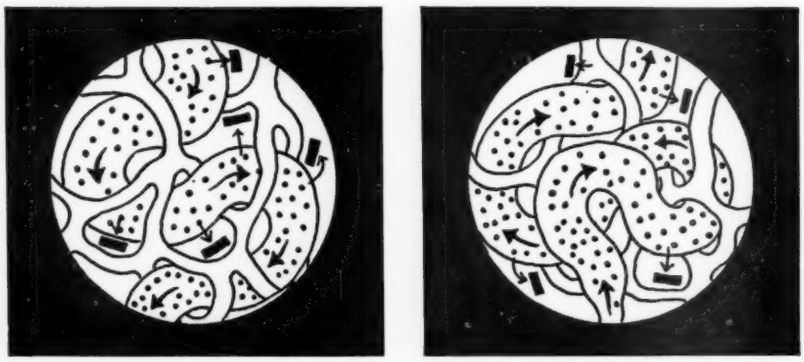

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Erratum: Dr. B. Roswit calls attention to an oversight in his article published in the February 1955 issue. On page 540 in the paragraph entitled Physics, "The half-life of Au-198 . . . " should read as follows: "The half-life of Au-198 is 2.7 days and the radiation spectrum contains a beta particle of 0.98 mev energy and a gamma ray of 0.41 mev."

from an editorial in the J.A.M.A.
(156:991, Nov. 6, 1954):

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1. Pollack, H., and Halpern, S. L.: Therapeutic Nutrition, Prepared with Collaboration of the Committee on Therapeutic Nutrition, Food and Nutrition Board, National Research Council, Baltimore, Waverly Press, 1952.

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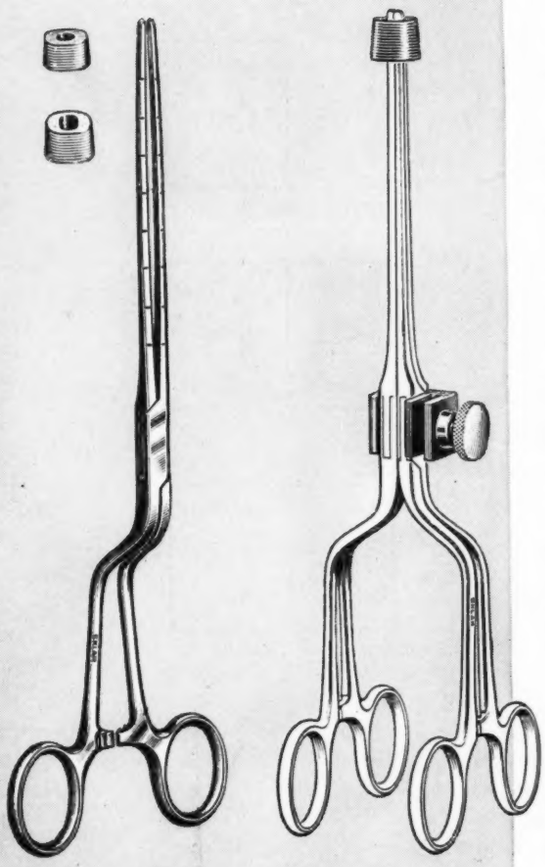

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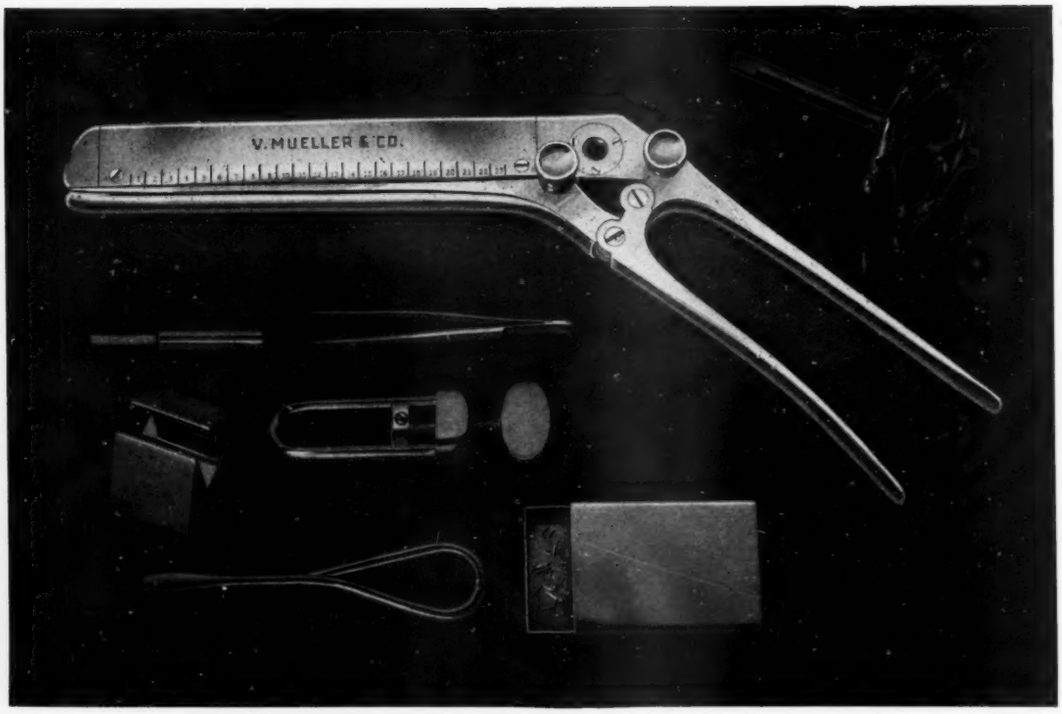

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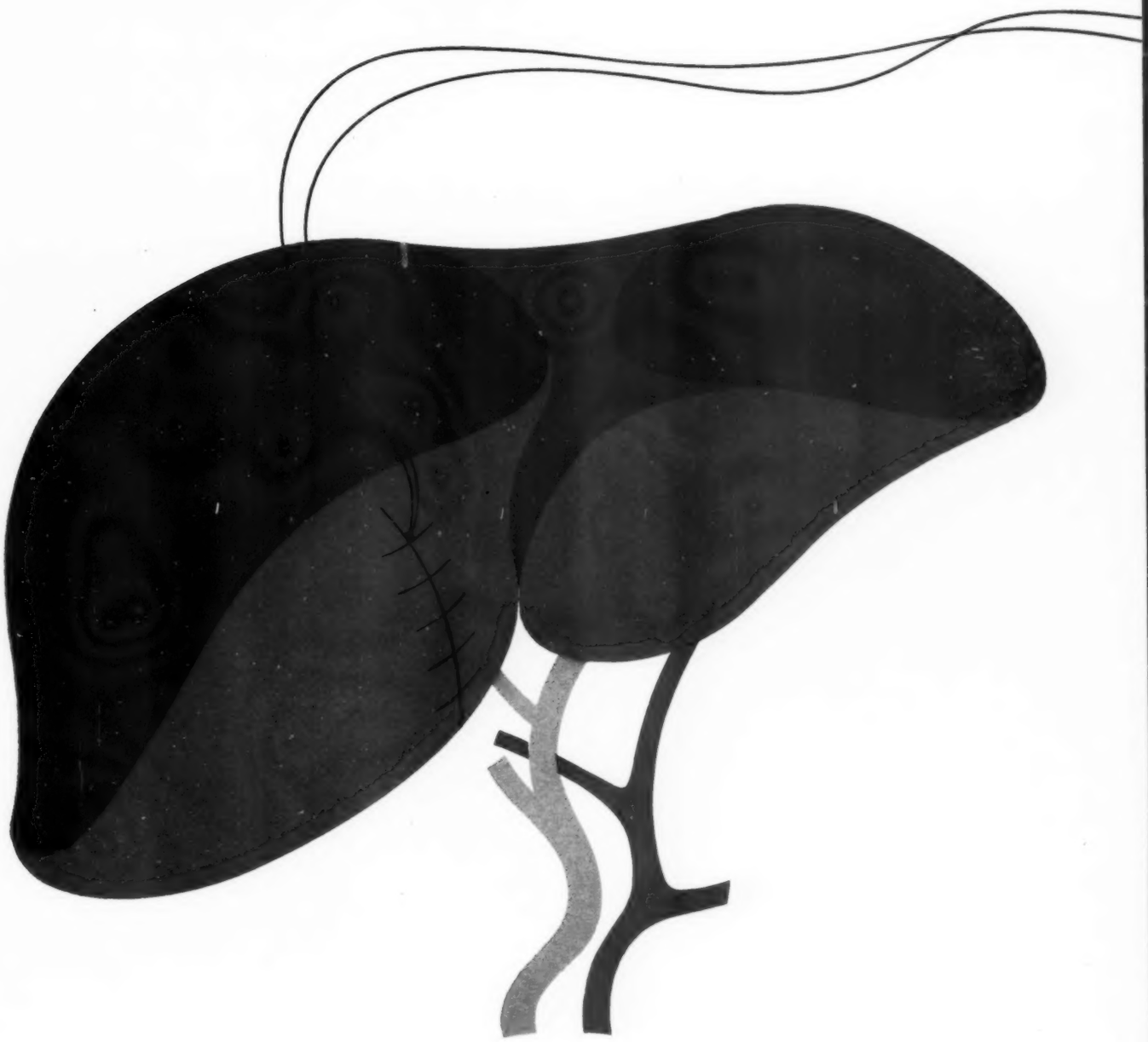

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Joseph, M.: Am. J. Surg. *87*:905, 1954

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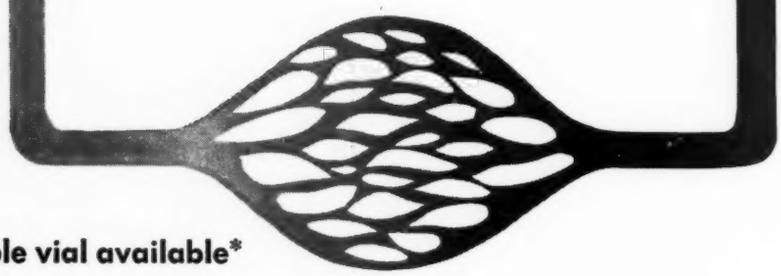

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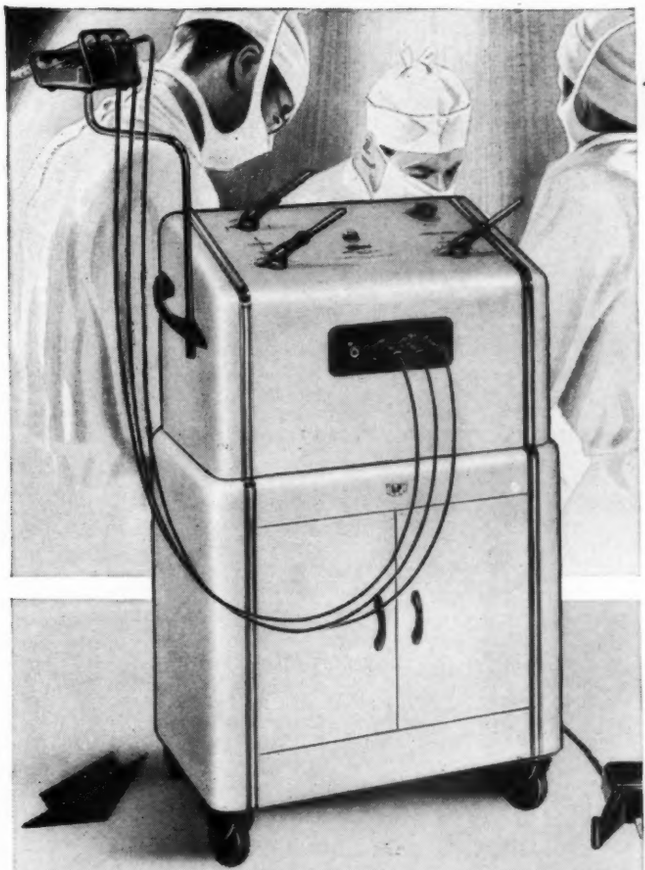

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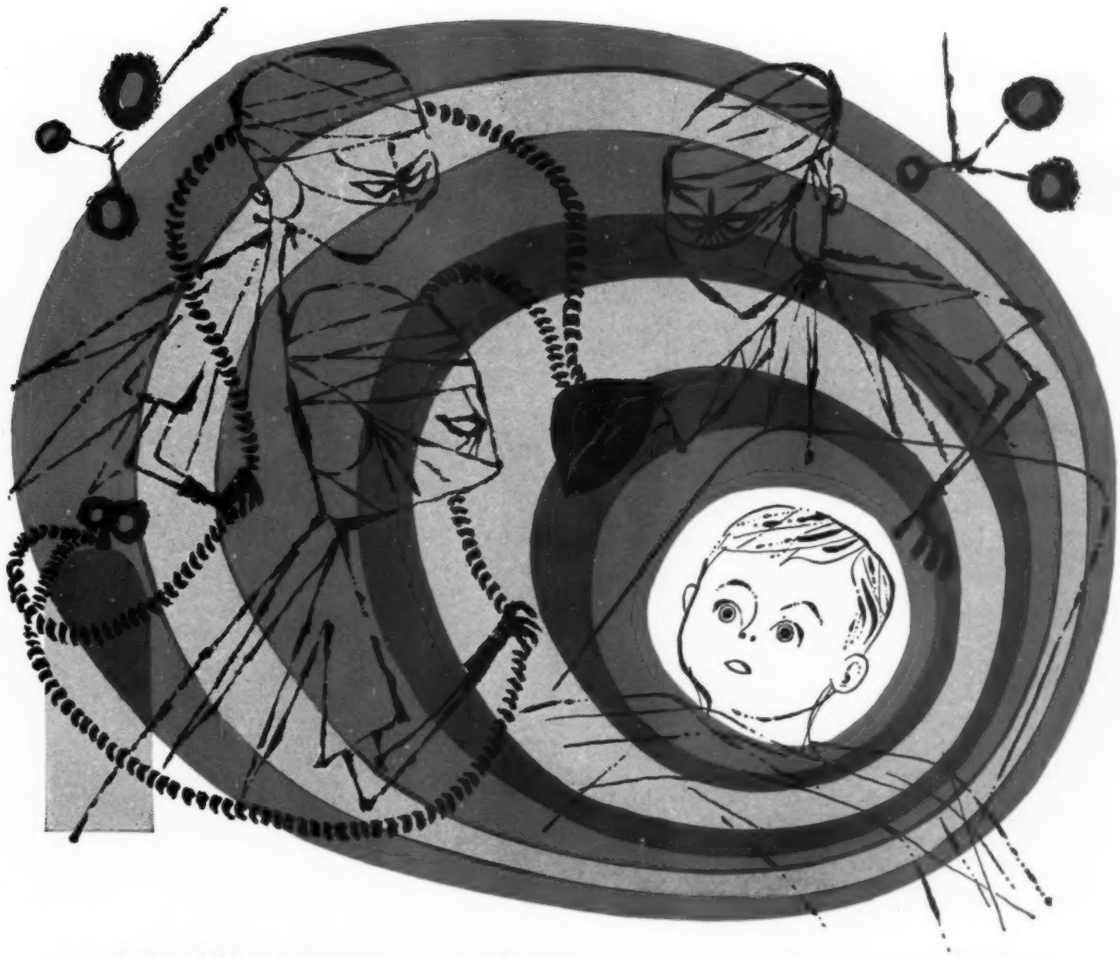

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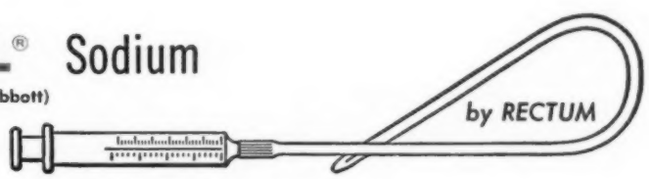

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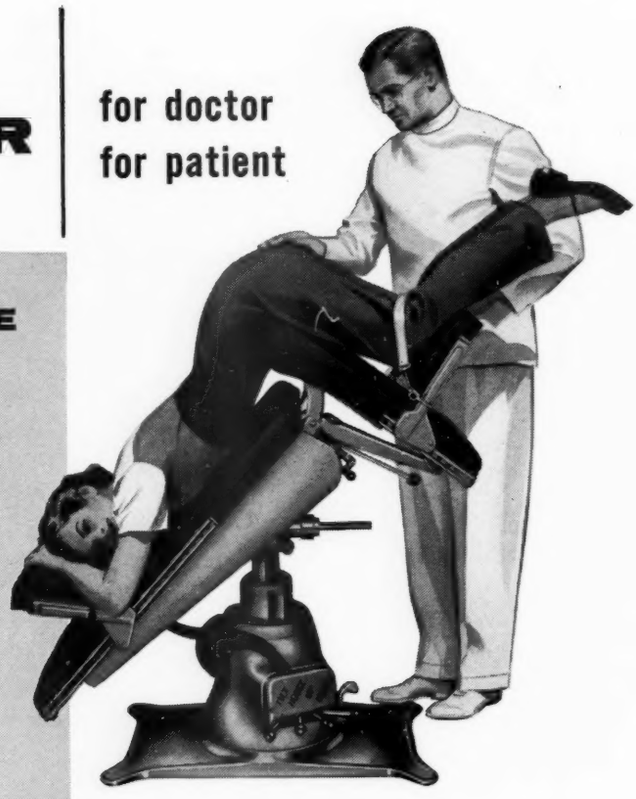

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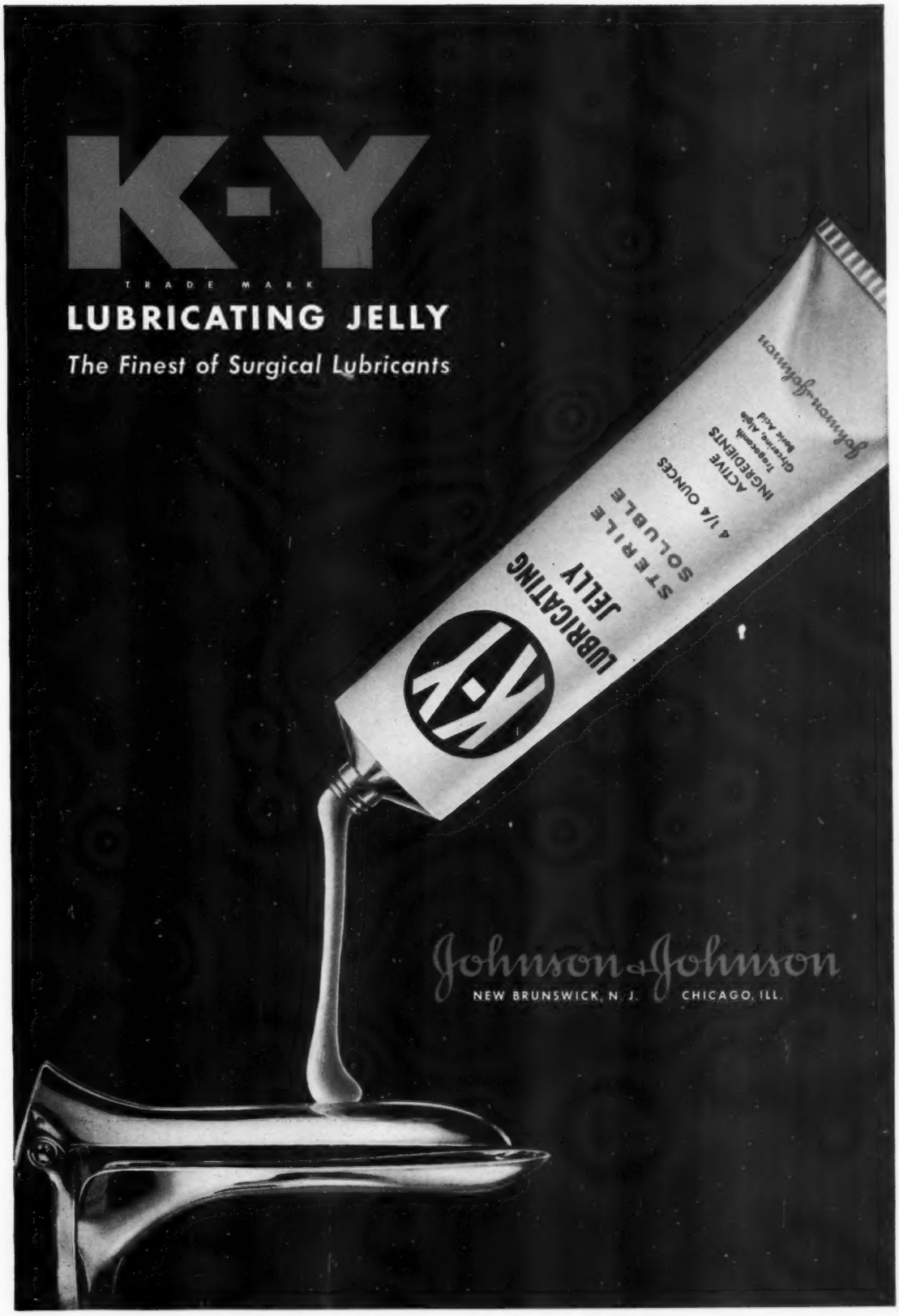
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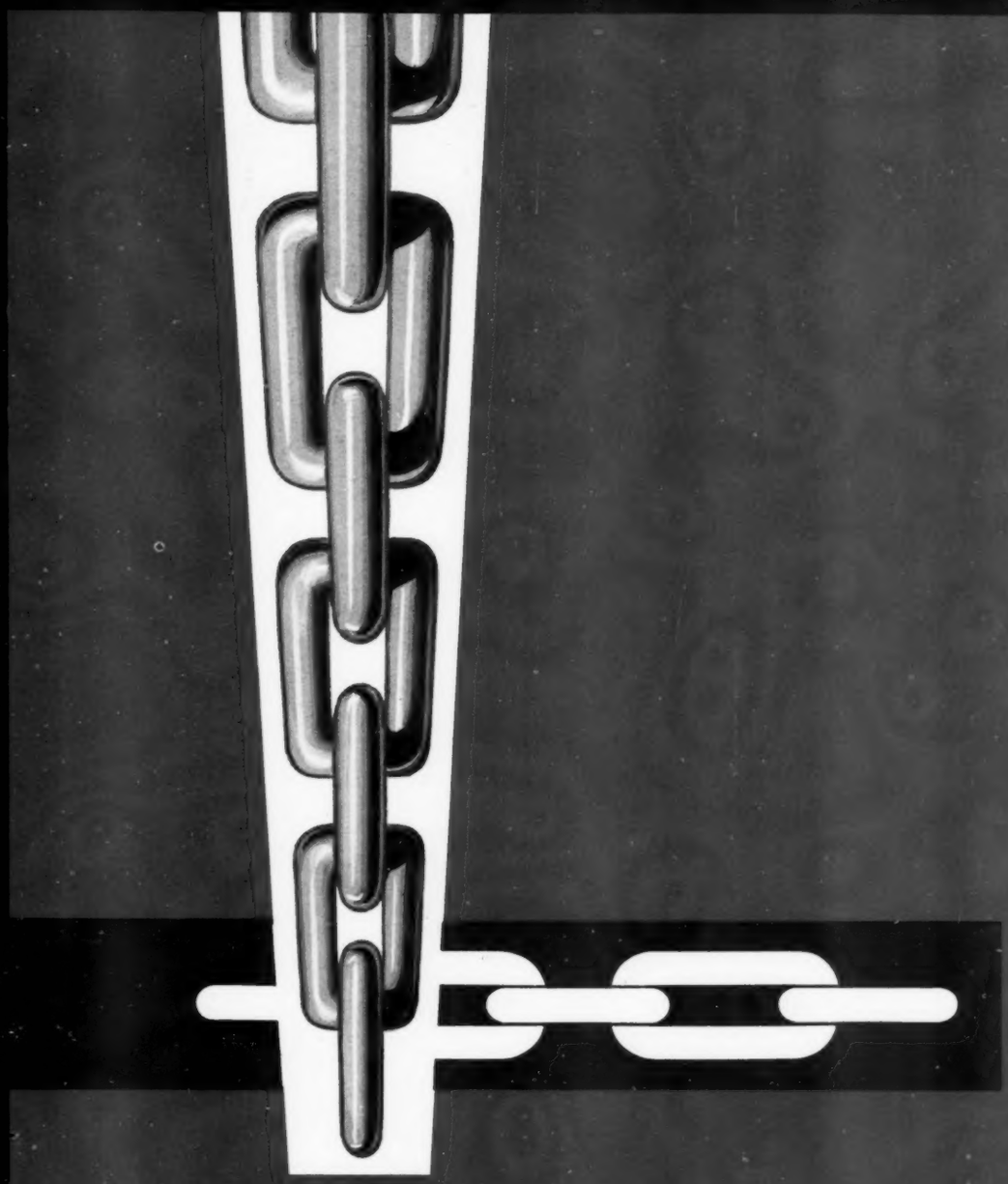

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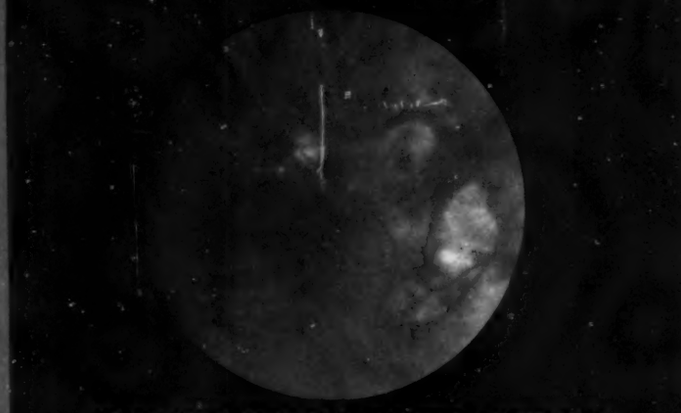
Minimal bleeding after Adrenosem therapy facilitates surgery and promotes healing.



Anticipation of recurrent hemorrhage and visual defect is high in hypertensive patients.

After Adrenosem therapy. Note exudative areas. Maintenance therapy checks further hemorrhage.

Mastoidectomy with a bloody field obscures view, requires frequent suctioning.

After Adrenosem therapy. Note clearer operative field with minimized bleeding.

Multiple extraction without Adrenosem. Note seepage. Frequent suctioning is required.

After Adrenosem therapy. Note clearer field. Minimal bleeding facilitates surgery and promotes healing.

Adrenosem®

Salicylate *(brand of carbazochrome salicylate)*

Adrenosem is specific for conditions characterized by increased capillary permeability allowing oozing and seepage bleeding. To prevent seepage bleeding due to capillary permeability it is necessary to maintain tone of the capillary wall. This is supported by Pappenheimer's[1] work on capillaries. In cases of capillary permeability it is postulated that the connective material between the cells, which form the capillary wall, has lost its tone and allows the erythrocytes to pass through.

To confirm the action of Adrenosem in establishing capillary integrity the cheek pouch of a hamster was irritated with snake venom, which has the property of making the capillaries more permeable.[2] A great many petechiae appeared on the surface and a 500 X magnification showed the capillaries with extravasation of erythrocytes. Another animal was treated with Adrenosem, and 30 minutes later, the same amount of snake venom was used to irritate the cheek pouch. Microphotographs of the same 500 X magnification show the intact capillary walls and the actual blood cells coursing through the capillaries, without signs of escaping erythrocytes.

Fig. 1—*Trauma from snake venom produces hemoconcentration and stasis, indicative of altered vascular permeability.*

Fig. 2—*Trauma does not produce petechiae following Adrenosem injection.*

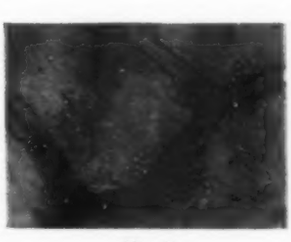


Fig. 1

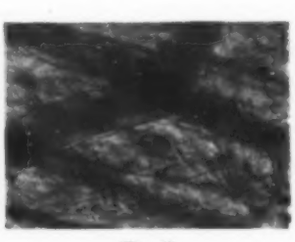


Fig. 2

Action

A systemic hemostat, Adrenosem restores capillary integrity by maintaining tone of intercellular tissue in the capillary wall. Adrenosem is unlike any hemostat available to medicine.[3,4] It does not interfere in any way with the blood clotting mechanism or its component parts. There is no sympathomimetic action and the blood pressure, cardiac rate and volume are not affected. Adrenosem may be administered simultaneously with any type of anesthetic, anticoagulant or vitamin K and heparin. Adrenosem will not interfere with the action of these agents.

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BIBLIOGRAPHY

While the hemostasic action of epinephrine and related compounds has been recognized for a long time, certain characteristics limited their usefulness. A product of the metabolism of epinephrine seemed to offer the most promise. Given the name, Adrenochrome, this compound was studied extensively in both European and American centers. The handicap to wide use of Adrenochrome was its instability, so efforts were directed to find a stable modification that would retain the physiological activity. The answer to this proved to be the monosemicarbazone of Adrenochrome. Further research demonstrated that this compound could be made soluble enough to be practicable as an injectable solution, by transforming it to a sodium salicylate complex. This process has made possible Adrenosem Salicylate, a potent therapeutic agent which fills an important need in medicine.

1 *Pappenheimer, John R.: Passage of molecules through capillary walls, Physiol. Rev. 33:387-423, 1953.*
2 *Fulton, M. D., Department of Biology, Boston University: Personal communication, 1954.*
3 *Sherber, Daniel A.: Adrenochrome complex in the control of bleeding, Am. J. Surg. 86:331-335, 1953.*
4 *Roskam, J.: Arrest of Bleeding, Chas. C. Thomas, Publisher, Springfield, Ill., 1954*
5 *Peele, J. G.: Adrenosem in the control of hemorrhage from the nose and throat (in press).*
6 *Bourgoyne, J. R. and Riddle, A. C., School of Dentistry, University of Tennessee: Personal communication, 1954.*

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Ampuls, 5 mg., 1 cc.: packages of 5.
Tablets, 1 mg. (s. c. orange): bottles of 50.
Tablets, 2.5 mg. (s. c. yellow): bottles of 50.
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- preoperatively to control oozing during surgery and provide clearer operative field: one to two ampuls (5 to 10 mg.) every two hours prior to surgery for two doses.
- postoperatively to prevent hemorrhage and check oozing: one to two ampuls (5 to 10 mg.) every two hours until there is no indication of undue bleeding. To maintain control, one ampul may be administered every three hours or 1 to 5 mg. orally t.i.d.
- to control active bleeding: one ampul (5 mg.) every two hours until bleeding is controlled; frequency of dose may then be diminished.
- to control mild, low-grade bleeding: one ampul (5 mg.) every three or four hours until bleeding is controlled; then 1 to 5 mg. orally four to five times daily until bleeding ceases.
- maintenance dosage to prevent bleeding in conditions where small vessel integrity may be impaired: 1 to 5 mg. orally t.i.d.; if bleeding ensues, dosage may be increased 1 to 5 mg. orally every three or four hours; if bleeding persists, oral dosage should be supplemented with one ampul (5 mg.) daily.
- pediatric dosage: up to four years of age—1 mg. intramuscularly or orally with same frequency as for adults, until bleeding is controlled. From four to twelve years of age—one-half the adult dosage as indicated.

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References: 1. J.A.M.A. 153:1516, 1953. 2. M. Clin. North America 27:189, 1943. 3. Surgery 18:200, 1945. 4. N.N.R. 1954, p. 107.

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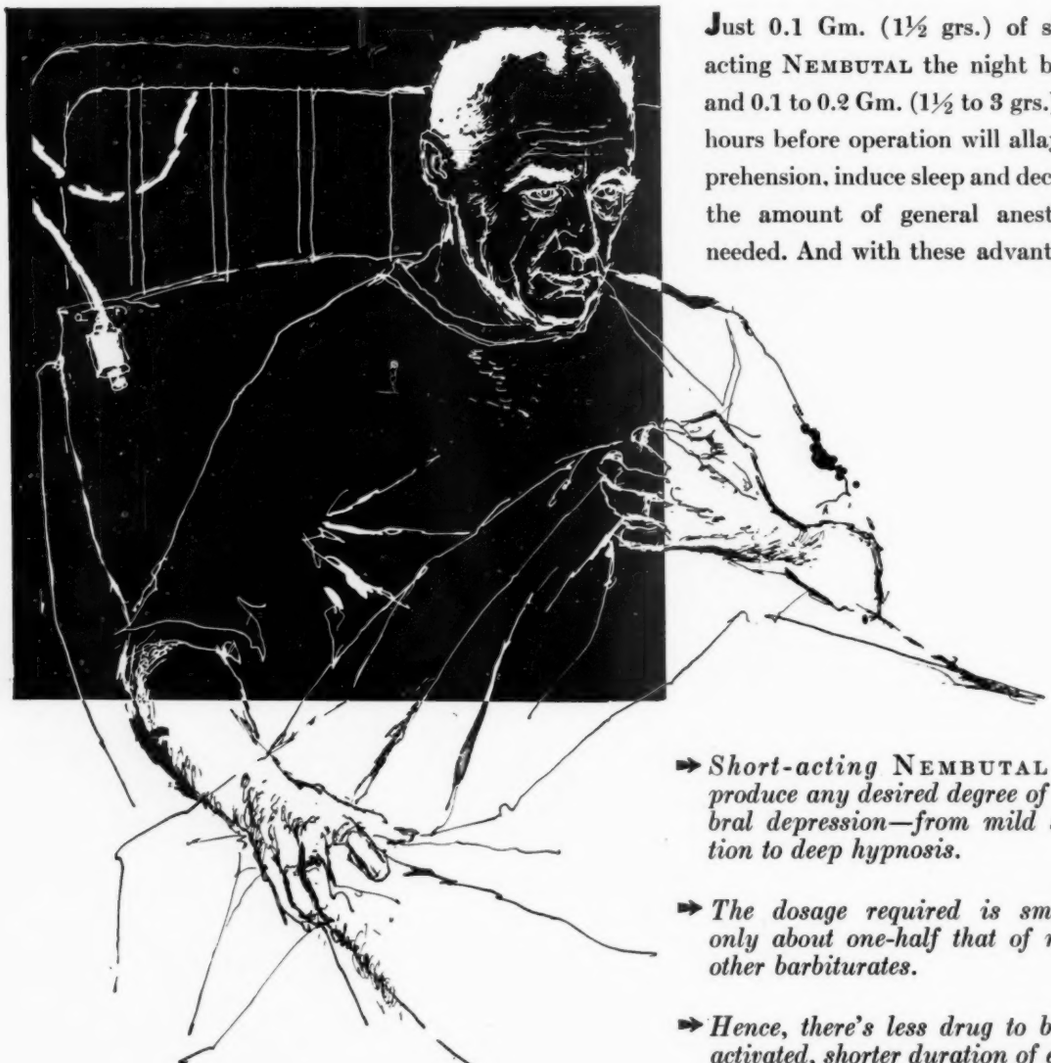

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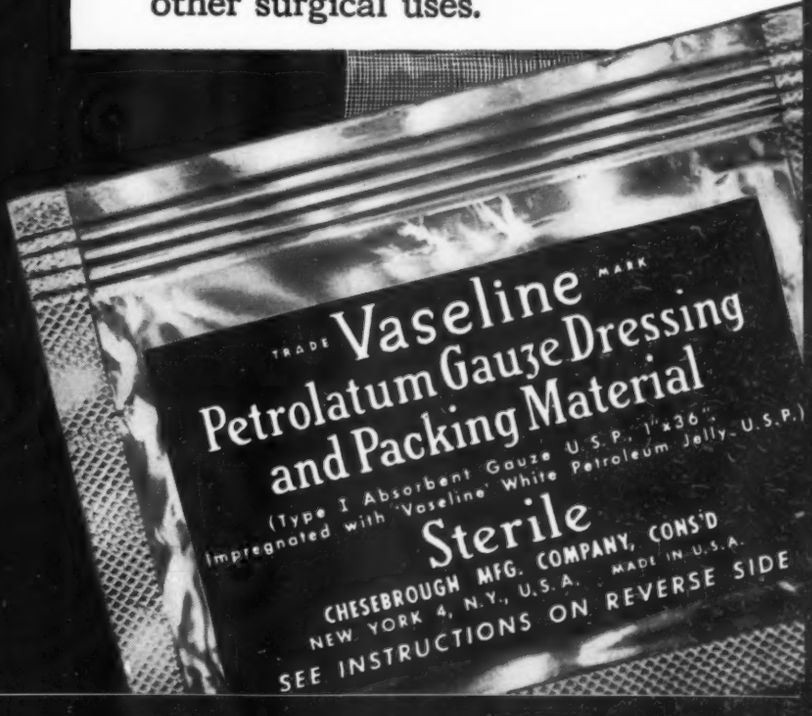
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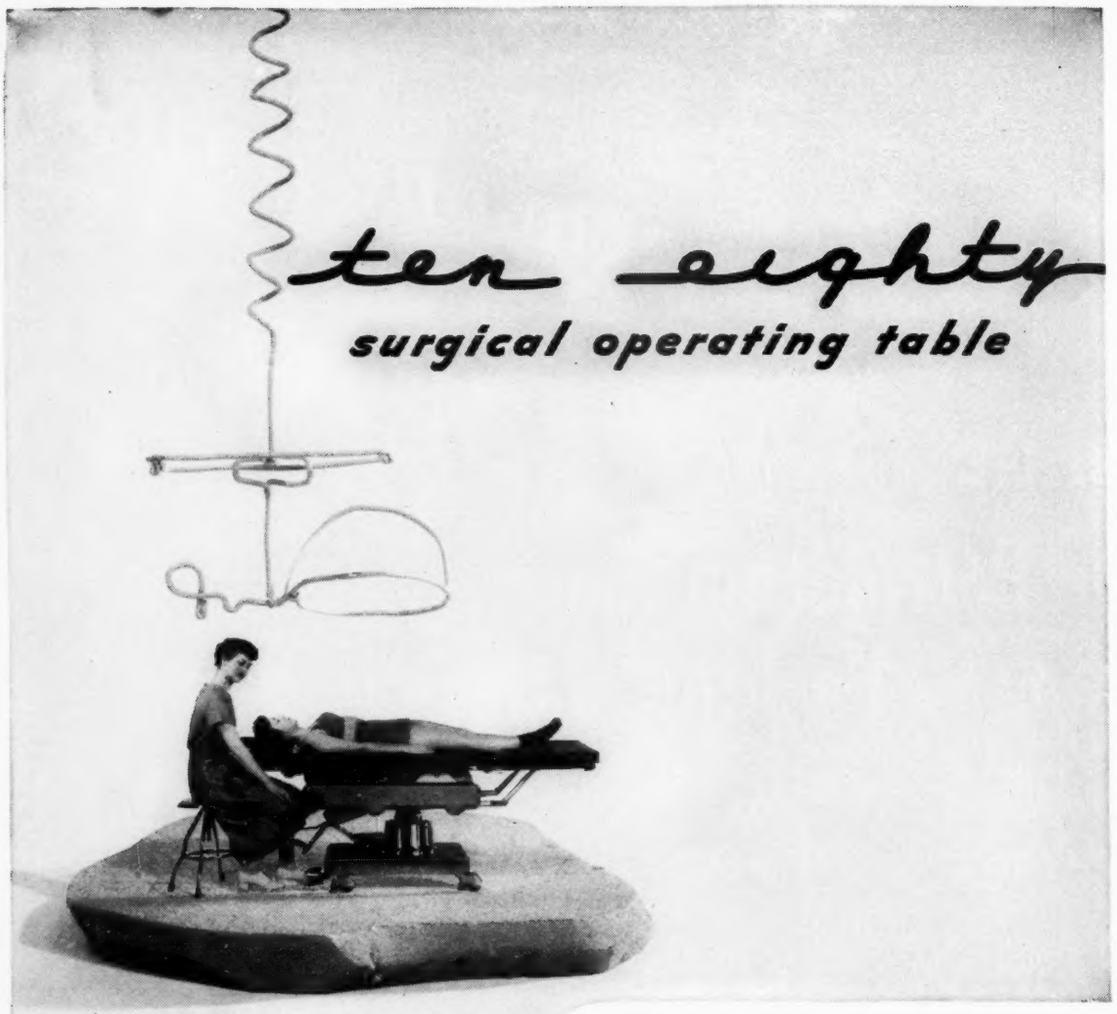

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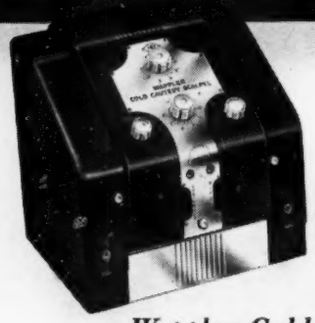

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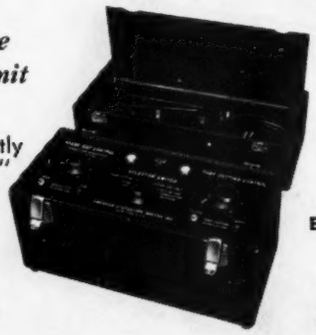

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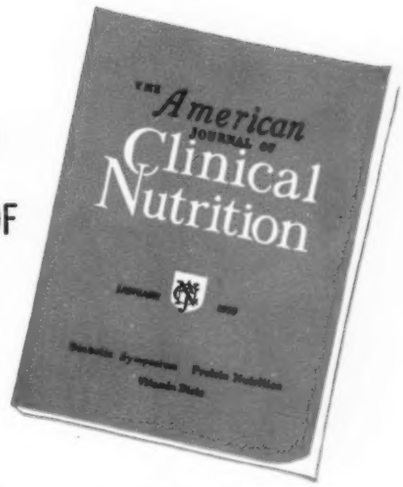

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THE BREEDING AND CARE OF A GREAT SURGICAL SOCIETY

ESLIE ASBURY, M.D., *Cincinnati, Ohio*

IT is extremely gratifying to be an original and continuing part of an organization one has lived to see come of age. To go back to its inception, at the 1937 meeting of the Western Surgical Association in Indianapolis I presented a paper on hip pinning, the only one there having to do with trauma. At one point during the meeting Drs. Carothers, Speed, Gilcreest and I were standing in the hall bemoaning the absence of such papers at surgical meetings, the poorly organized amenities for the care of the injured in most hospitals, the lack of interest in the teaching of the surgery of trauma and the fact that many respectable surgeons and orthopedists "looked down" on this work, thus too often leaving the care of the injured either to uninspired residents or conniving ambulance chasers. We agreed that the orthopedists and others in limited specialties were doing excellent work in their fields, but we believed that the over-all problems of trauma, which would necessarily always be in the field of general surgery, were being neglected by the general surgeons.

We brightened when we recalled that some distinguished general surgeons were still making contributions in this field (Cotton, McKim, Phemister, Speed, Magnuson, Robert Carothers, Scudder, Kennedy, Venable, Beekman, Murray, Darrah, Coley, Noland, Gurd, Marble, Bancroft, Sherman, etc.). All at once the thought struck that since we were neither fish, flesh nor fowl, why not get a strong group of like-minded general surgeons, orthopedists of broad experience and representatives of the surgical specialties together in a society? My own part, if any, was merely the suggestion to form such a society. The actual hard work of organization was done largely by Drs. Ralph Carothers and Morrison, ably assisted by Drs. Gilcreest, Metz, Hegner, Speed, Penberthy, McKim and others. A nucleus of distinguished surgeons of the American College of Surgeons, and the Canadian, Western, Southern and American Surgical Associations, together with such men as Henderson and Campbell of the American Orthopedic Association, cooperated in the founding effort. The rest is history.

For the benefit of our newer members, here is my personal version of the aims of the founders: (1) to form a society of maneuverable size composed of leading interested general surgeons and worthy representatives of the surgical specialties of the United States and Canada; (2) to provide a meeting place for discussion at the highest level of the science, art and practice of the surgery of trauma; (3) to dignify the practice of the surgery of trauma; (4) to encourage research, better organization for the teaching of trauma, greater emphasis on the knowledge of trauma by the diplomates of the various boards, and to explore the need of a sub-board for trauma under the General Surgical Board; (5) finally, as Dr. Johnston so aptly

put it, to keep the care of the injured free and open to all qualified men whether members of this or any other organization.

The founders did not wish to usurp the prerogatives of any group. They had no grudge against any specialty. They wished to cooperate with already functioning organizations.

The size and aims of our society would make it impossible for us to rival the wonderful over-all job covered by the American College of Surgeons, organized as it is to contain all qualified men and to take leadership in instructing not only the profession but also the public in legislative, preventive and organizational problems relating to trauma. If there were any misgivings about us at the start, they were soon dispelled by the type of our membership and our evident sincerity.

Since our society has taken its place alongside the great surgical organizations, in what direction will the future take us? This will depend upon the type of new members and officers selected through the years. Our success is due to the proper original selection of breeding stock. Unconsciously, the best principles of genetics were followed. Eminent men of any age, of all specialties, of all surgical organizations, were the sires. They provided out-crosses and hybrid vigor, accentuating the desired dominant characteristic (interest in trauma).

We cannot continue to breed from proved sires, but, like all good breeders, we must select our new members from the best younger prospects. A high proportion of the membership, of course, should be general surgeons, along with a fair representation of the surgical specialties. We are proud of our academicians, many of whom are our most illustrious members and important contributors. We could not get along without them and we should like more of them, but I venture they agree that we must seek a fair ratio between surgeons in private practice and teachers of surgery, and that no group should ever dominate this society.

Our membership is of such breadth that we can more and more cooperate with the American College of Surgeons, the American Medical Association and the schools and hospitals in formulating programs for better teaching and training in trauma. It was gratifying to note that the first instruction on this year's card given the examiners for the Surgical Board stressed trauma (suggestion of our President-Elect Warren Cole); five members of our group helped examine the candidates at Cincinnati.

Our society is ideally situated to assist the General Surgical Board in setting up a method of high level certification of surgeons in the field of trauma. We believe this to be the only justifiable approach since it is not our wish to form merely another board. In fact, it would be ideal if there were only two main boards, Medicine and Surgery, with all other boards subsidiary to them. This would hasten the maturity of our profession and unify our efforts to make better doctors of us all.

Thorough training in surgery and the specialties is of recent origin and still requires direction in this period of vast expansion in hospitalization. Boards seem to be the only answer, at least at this time. The criticism of regimentation against the boards and against the American College of Surgeons and the American Medical Association for their standardizing activities are not justified since these are voluntary actions carried out by the profession itself. They are merely further steps in *self-imposed discipline* begun half a century ago with the reform of the medical schools.

If we are making any mistakes, all of us should try to help correct them because all good things, even boards and sub-boards, carry potential pitfalls. In using the boards and our great national organizations we must avoid the evils of bureaucracies, avoid splintering the profession into guilds or trade unions, avoid silly labels, and avoid unnecessary subspecialties, classifications and hospital regulations. In the prevention of these our society, because of its broad membership, is again in an ideal situation to help. Admittedly, a certain amount of specialization will always be necessary, but as our secondary school and undergraduate curricula are improved and become better integrated and shortened, and as our postgraduate training programs broaden and mature under the prodding of the boards, possibly most of us can still be doctors in the broadest and best tradition.

A Second Look at Surgical Care in Major Catastrophes

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UNFORTUNATELY, man as yet has not reached that Utopian State of progress where collectively he can solve his problems through the medium of round table conferences. As a result, for an undetermined period of time, we shall find ourselves living under the constant shadow of sudden total war. Future warfare will not differentiate between the military and civilian population, because to destroy the source of the bomber or aircraft carrier is just as effective, if not more so, than to destroy the finished product in the zone of combat.

Nothing in our history has prepared our nation adequately for the mass casualties which will result in the event of a third world war. Future atomic warfare will be carried on swiftly, vigorously and ruthlessly with the larger proportion of the casualties occurring among our civilian population. Areas of our country will be bombed with two objectives in mind: (1) to neutralize as completely as possible highly industrialized areas engaged in the manufacture and transmission of weapons of warfare; and (2) to destroy populated areas, in which event the psychologic impact of devastation might break the morale of the American people.

The American doctor may accept one of three philosophies in facing the problem of atomic warfare: (1) a fatalistic attitude that catastrophe will be so absolute that little can be accomplished in the salvaging of human lives; (2) that, as in the case of England during the early phase of the last world war, a system of medical care can be forged in the fire of enemy attack; and (3) that there is no time to waste and that American medicine must accept her responsibility and prepare for any eventuality. The first philosophy is not only grossly inaccurate but also not in keeping with the traditions of American medicine. The second philosophy is fallacious in that we are no longer planning a defense in terms of conventional attack, but rather a survival in the face of swift atomic destruction, when the initial blow may well be the most critical. The third philosophy is the one we must accept, building our medical plans on all available experience both past and present, gathering data and filling gaps in the chain of therapeutic evidence by research and a pooling of medical knowledge.

Evaluation in retrospect of the results of the medical care given during the Korean action reveals a story of which American medicine may well be proud. Never in the history of modern warfare has a wounded man faced such high odds in favor of survival. During the Civil War of every 100 men wounded in action (that is, those who survived initial injury long enough to receive any type of medical care), approximately fourteen died. In World War I this percentage was reduced to eight. During World War II only 4.5 per cent of those wounded died and of those injured during the Korean fighting, there was a mortality rate of only two of every 100 wounded.

These dramatic results certainly are not accidental but are due to a variety of factors; such as the high caliber of professional competence, the rapid and safe evacuation of patients, the availability of whole blood and improved pharmaceutical products such as the newer antibiotics, progress in the technics of the therapy of trauma such as vascular surgery, the development of the armored vest, and many other therapeutic adjuncts. It is on experience such as this that we must build and constantly revise our medical plans in preparedness for any eventuality.

As the result of carefully designed experiments carried on by innumerable workers in our universities and hospitals under the guidance of the Division of Medical Sciences of the National Research Council, and subsidized by the Army, Navy and the Air Force, as well as the United States Public Health Service, and as the result of painstaking experiments carried on by the Surgical Research Team of Korea of the Army Medical Service Graduate School and the 406th Medical General Laboratory of the United States Army, we have available a wealth of information which, if properly exploited, will aid immeasurably in the care of the severely injured civilian or soldier, sailor, marine or airman. The importance of disseminating such information as may be useful in therapy must be self-evident, for morbidity and mortality will bear a direct relation to the efficacy of therapy and to the extent to which we have made available to those who will be responsible for therapy, data of practical importance.

SHOCK

The prevention and treatment of shock is of primary importance following severe injury. Although much remains to be known about various physiologic mechanisms related to shock, there can be no question but that shock following injury is associated with a deficiency in the available blood volume. There has been much controversy as to just when the diagnosis of shock should be made. There are those who believe that low blood pressures in themselves are not pathognomonic of shock, but that they are significant only if they are associated with other signs of shock. It is our considered opinion that in the presence of mass casualties such attempts at differentiations are not possible. It is far safer to diagnose mild shock following injury when the blood volume has resulted in a systolic blood pressure below 100 mm. of mercury, and to diagnose severe shock if the systolic pressure is below 60. In either instance, means must be taken as rapidly as possible to restore an effective circulating blood volume.

With the knowledge at present available, it would be worthless and hazardous to lay plans for the institution of "hibernation" after the method of Laborit and his associates. While some type of therapy leading to decreased metabolic demands of important viscera may finally prove to be effective in the therapy of shock, scientific knowledge is not now available which would lead us to propose such therapy upon other than an experimental basis.

The only way now known of restoring an effective blood volume is to introduce into the circulation fluids containing colloids which will remain in the circulation over a considerable period of time.

If the hemorrhage has been severe, especially in elderly individuals, blood should be administered if this is available. There is always the danger, following severe hemorrhage, that the administration of plasma expanders may so dilute the oxygen carriers of the blood, the red cells, as to intensify shock. We have now available the methods of collecting large amounts of blood. In the presence of mass casualties we must have available large amounts of low titer o blood for there will be no time for typing, cross-agglutination and the other tests that are commonly employed in well conducted hospitals and laboratories. We too often forget that whereas small amounts of blood may have no effect upon the progress of the shock process, large amounts of blood may save the life of the patient.

The recent experience in Korea, which demonstrated that severely injured casualties in serious shock could be resuscitated when twenty, thirty or even forty units of blood were administered, emphasizes the importance of this concept. More seriously injured casualties will die from too little blood than from too much.

It must be readily agreed by everyone that in the presence of mass casualties we shall never have enough blood available for the treatment of these casualties. We will, therefore, be forced to depend upon the group of agents, presently available or those which may become available, which have come to be known as the plasma expanders. They are not involved in oxygen carrying capacity. They are purely colloids which remain in the circulation for variable periods of time depending upon molecular size and which, as the result of the colloid osmotic pressure which they exert, keep fluids in the circulation. Of those which have received intensive study, American made dextran, according to the specifications laid down by the National Research Council, and polyvinylpyrrolidone (PVP) also of specified molecular sizes, can readily be produced in

sufficient amounts within the standards designated for widespread distribution. It must be remembered, however, that when these agents are used, they cannot take the place of blood, and while they may extend the usefulness of blood, they are in no sense blood substitutes. In the severely injured casualties in Korea, the Surgical Research Team demonstrated that one unit of a plasma expander to two units of blood provided an optimum for therapy and for the extension of the usefulness of the blood available for casualties.

When blood is not immediately available, plasma expanders can undoubtedly be used in larger amounts, but as soon as possible individuals receiving expanders only should receive blood at the earliest possible moment if they are in severe shock.

Shock teams should be organized in every one of our major communities. Large numbers of intelligent people should be trained adequately to take blood pressure and to administer blood and plasma expanders when the indications suggest that shock is present or is imminent. We have previously taught large groups of individuals to splint extremities, to stop hemorrhage, to apply tourniquets and to dress wounds with a temporary sterile dressing. We must extend this training by teaching first-aid workers how to administer fluids and what fluids to administer under varying conditions of injury.

ANTIOBIOTIC THERAPY

There has been considerable controversy as to whether the motivating organ associated with the development of irreversible shock is the liver or whether the presence of severe shock is motivated by bacteria passing from the intestinal lumen into the blood stream.

It is well known that every wound sustained by injury is contaminated even though it is covered by sterile dressings before the casualty is transported from the site of injury. Clostridial infections are common and are said to be more common in wounds sustained in the summer than in the winter. The Surgical Research Team in Korea found them to be approximately twice as common in the wounds sustained during the summer as in wounds sustained during the winter. It is interesting to note that this team also found that the size of the wound did not appear to be related to the incidence of contamination with clostridial organisms. In addition to the clostridial organisms, one may find in these wounds all of the organisms commonly found in the soil and in the air of the area, as well as in the respiratory tracts of the individuals sustaining injury and of the personnel taking care of them. Many strains of staphylococci and streptococci are frequently present as well as colon bacilli and other organisms.

The Committee on Surgery of the National Research Council and other groups have made suggestions regarding the control of infection in such wounds. In World War I we learned that adequate débridement prevented gas gangrene, on the one hand, and spread streptococcal infections, on the other. During the Korean conflict, we had available for the first time a wide variety of antibiotic agents which could be used for the prophylaxis of wound infections. Since all the information, which is presently available from studies made during World Wars I and II, has shown the presence of pathogenic aerobes and anaerobes in wounds before initial surgery, we must as rapidly as possible attempt to ascertain which of the antibiotics should be used following wounding, the dosages to be administered, and the period of time over which they normally should be administered.

Extensive débridement of all devitalized tissue in the early institution of adequate antibiotic therapy will, we believe, reduce still further the incidence of serious infections in any future conflicts. Evidence gained during the Korean conflict, and soon to be published, will show that aureomycin and terramycin inhibit the growth of clostridial organisms in the lowest concentrations of any of the antibiotics now available. In Korea these two antibiotics were found in *in vitro* studies to be much more effective against the organisms, both aerobic and anaerobic, present in wounds than were penicillin or chloramphenicol. Furthermore, it is interesting to note that the administration of penicillin in dosages varying from 300,000 to 600,000 units intramuscularly, shortly after injury, does not prevent the development of a bacteriemia in the casualty. The most interesting part of this aspect of the study made by Howard and his group in Korea showed that "the degree of shock, the type of injury, the time lag and the previous antibiotic therapy (penicillin) did not effect the incidence of positive cultures."

We must have available large amounts of the broad spectrum antibiotics. We must as rapidly as possible attempt to obtain additional information on the effectiveness of the wide variety of antibiotic agents now available for therapy on the common contaminants of wounds. Only when the circulation is severely hampered should any of these substances be administered intravenously. Intramuscular administration of these drugs is a simple process and if further experience has proven it to be useful, it should be taught to those who would participate in the care of our casualties.

Aureomycin and terramycin given in adequate dosages by mouth will inhibit, to the greatest extent, bacterial growth in wounds. If for one reason or another, these substances cannot be given orally, they can be administered by parenteral route, if preparations are available for such therapy. Every effort should be made to make available preparations of aureomycin or aureomycin-like agents or terramycin or terramycin-like agents for intramuscular and intravenous therapy.

BODY ARMOR

The body armor used in Korea proved so effective in reducing the number of serious battle casualties among Korean troops that it has been suggested that similar devices be considered for civilian defense in this country. The authors stated, "The battlefield is no longer confined, and the spector of atomic bomb and H-bomb blasts on homeland cities is an accepted prospect. Injury from flying debris, such as masonry, metal, and glass is of great importance after such blasts, and conceivably the use of body armor could lessen appreciably the staggering morbidity and mortality anticipated in such a mass civilian disaster."

The body armor used by the army in Korea consisted of a vest of nylon armor which weighed about 8 pounds. The marines used an armored vest quite similar in shape, weight and size which was made of fiber glass plates. This lightweight shield not only provided a degree of protection against flying missiles but also against small arms fire. It lessened the severity of the wounds that were received when the vests were perforated by small arms fire or by other missiles or shells. It has been reported that 68 per cent of all missile hits on armored vests worn in combat were deflected.

The use of the armored vest has presented certain problems, particularly those of an increase in the number of severely traumatized extremities. In the past, prior to the use of protective armor, wounds of the trunk often resulted in death, whereas now fatal abdominal and thoracic injuries are prevented permitting survival of a patient with seriously mangled extremities. This accentuates the need for constant research in the field of nerve, vessel and bone trauma.

PATIENT EVACUATION

A second look at surgical care in major catastrophes cannot be complete without the consideration of the role played by improved patient evacuation in the lowering of mortality rates. During the Korean fighting there were over 400,000 patient evacuations with only five deaths due to transportation accidents. Each move of a patient by an airplane is designated as an evacuation. Hence the movement of a wounded man back to the United States might involve a series of two to four patient evacuations. A record such as this is amazing, to say the least, especially when one considers the hazards of flight in the combat zone. Comfortable and rapid evacuation of the severely wounded man plays a major role in the prevention of shock and permits an early surgical attack on the traumatic problem at hand.

SUMMARY

We have attempted to present some of the factors that must be considered in the care of mass catastrophes. It is of the greatest importance that such information be widely disseminated and thoroughly understood in order that we reduce the morbidity and mortality associated with catastrophic injury.

Reappraisal of the Treatment of Hemorrhagic Shock

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OUR purpose in returning to this subject at the present time is to put forward some aspects of the practical therapy of hemorrhagic shock which have undergone revision in the past two years. Before proceeding to the recent data on rapid intravenous transfusion as an alternative to intra-arterial transfusion, we would like to review the basis for the increasing interest in the role of the myocardium and coronary circulation in the outcome of severe hemorrhagic shock.

ROLE OF THE HEART, LUNGS AND CORONARY CIRCULATION

Our own interest in the role of the heart and lungs in the course of shock and resuscitation was stimulated by Eaton's fine paper in 1947. Eaton[1] noted a rise in pulmonary artery pressure above normal some forty-five minutes after withdrawal of 25 per cent of blood volume in dogs. He was able to correlate this rise with an increase in pulmonary moisture, and postulated a block to pulmonary blood flow within the lungs themselves. Although he did not measure left atrial pressures, he suggested that insult to the functional ability of the left heart might be contributing to this impounded pulmonary artery pressure.

In 1951 we pursued this line of inquiry further at McGill in the hope of establishing better control of the rate and volume of transfusion from the viewpoint of avoiding dangerous degrees of pulmonary congestion.[2] In addition to measuring systemic arterial and venous pressures and pulmonary artery pressures, a catheter was passed from a carotid artery through the aortic and mitral valves into a pulmonary vein. This was the first time that the equivalent of left atrial pressures had been studied in a closed chest dog preparation during shock. Animals were put through the Wiggers shock procedure and resuscitation.[3] It was found that Eaton's rise of pulmonary artery pressure was generally matched by a similar rise in pulmonary vein (left atrial) pressure, indicating that in some cases at least, the apparent pulmonary

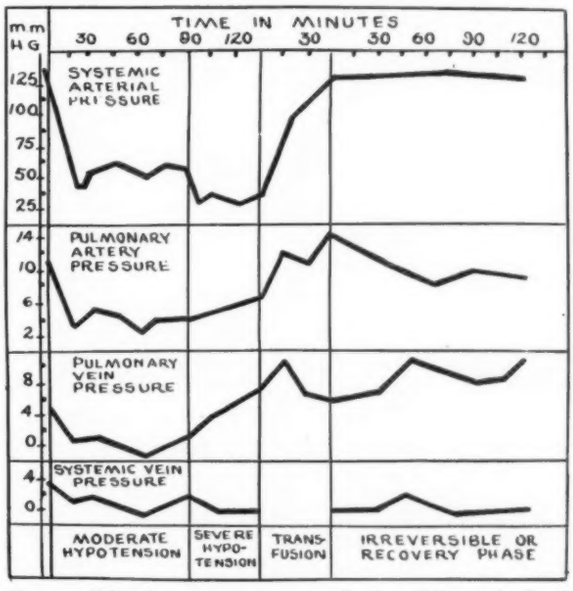

FIG. 1. Blood pressure curves during Wiggers' shock and resuscitation. It will be noted that the pulmonary arterial pressure rises during the period of severe hypotension and during resuscitation, but that this rise is paralleled by the pulmonary venous pressure. This animal maintained a high pulmonary venous pressure in the post-transfusion period, suggesting myocardial embarrassment rather than pulmonary blockade. Resuscitation in this case was by intravenous transfusion. (Courtesy of W. B. Saunders Co. From Rounthwaite, Scott and Gurd.[2])

blockade had its origin in the left heart. (Fig. 1.) This evidence of cardiac insufficiency occurred in both late oligemic shock and in the normovolemic stage of resuscitation. It occurred in the majority of animals but not in all; its relation to pulmonary congestion was not constant, but it appeared to occur with equal frequency whether resuscitation was by the intravenous

or intra-arterial route at similar rates of transfusion.

Sarnoff[4] has confirmed a rise in left auricular pressure in open chested dogs in shock, but noted also that some animals appeared to show a pulmonary congestive blockade which could not be related universally to left heart incompetence. Wilson, Fogelman and Reid[5] showed that a marked increase in pulmonary engorgement occurred in salt depleted dogs during shock and particularly during blood replacement. Thus the clear separation between strictly pulmonary and strictly cardiac effects in the pathogenesis of cardiopulmonary failure continues to elude our range of knowledge, and completely rational control of resuscitation is not possible.

Some further evidence that myocardial failure may become a factor in terminal shock may be summarized as follows: (1) Cardiac dilatation is a significant index of the onset of the terminal phase of shock (Kohlstaedt and Page[6]). (2) A decrease in stroke output may exist even in the presence of an elevated right auricular pressure (Wiggers and Werle[7]). (3) Electrocardiographic changes are observed indicative of disturbed myocardial function in both animals and in man (Wiggers[3]). (4) Diminished coronary artery flow occurs with marked decline in myocardial oxygen consumption, aggravated in the normovolemic stage of resuscitation by an increase in coronary resistance, apparently due to a perverse and ill timed vasoconstriction (Edwards, Reber, Siegel and Bing[8]). (5) In their recent fine experiments on the role of the coronary circulation Sarnoff, Case, Waithe and Isaacs[4] have demonstrated the following remarkable phenomenon: that direct augmentation of left main coronary flow, even while maintaining the same degree of hypotension and without increasing blood volume, will reverse an elevated left auricular pressure and cardiac dilatation, enabling recovery to proceed in otherwise irreversible shock. They were able to demonstrate a similar remarkable effect by the use of a sympathomimetic drug known as aramine®.

Case, Sarnoff, et al.[9] were the first to question the contention, put forward by the proponents of the intra-arterial route for transfusion, that this route possessed superior advantages in increasing coronary flow. They showed indeed that an increase in coronary flow was of prime importance in recovery from shock, but they demonstrated also that this was equally well accomplished by both intra-arterial transfusion (IAT) and intravenous transfusion (IVT) provided that the rate of transfusion was comparable.

INTRA-ARTERIAL VERSUS INTRAVENOUS TRANSFUSION

The large volume of enthusiastic reports in favor of IAT, so thoroughly reviewed in 1952 by Seeley and Nelson,[10] received an initial challenge by Aldrich and Morton in 1950.[11] These authors used short ten-minute periods of shock, followed by resuscitation by both routes at similar rates. They observed no difference in effectiveness between the two methods. Three papers were presented to the Surgical Forum of the American College of Surgeons in 1953, covering between them a wide range of rates and methods of control, and concluding unanimously that the two routes were equally effective provided that the rates of transfusion were equal. The fine paper by Maloney et al.[12] showed in addition that the hydraulic effect of IAT in elevating arterial pressure is insignificant at the rates of transfusion employed clinically. Also, blood transfused by either route mixes equally well with the general circulation without evidence of pooling. Again, they demonstrated radiographically that direct perfusion of the coronary arteries by arterially infused blood occurs only when the output of the left ventricle is negligible or non-existent. Richards and Hansen,[13] in their contribution, found no difference in venous pressure rise during resuscitation by either route.

In our own paper presented at the same time[14,15] we set out to study the relative advantages of IAT and IVT in dogs with myocardial infarction. This work was in line with the increased interest in geriatric surgery.[16] It was postulated that IAT might be advantageous in resuscitating shocked animals with damaged hearts in that it was thought at that time to be less liable to induce heart failure. Indeed, IAT had been recommended in the treatment of acute clinical coronary infarction.[17] Dogs were prepared by ligation of the descending branch of the left coronary artery, and survivors were submitted six or seven weeks later to controlled hemorrhagic shock and the two routes of transfusion compared. To our surprise the infarcted animals proved

able to withstand the full Wiggers shocking procedure, and responded to resuscitation in a manner entirely comparable to the response of normal controls. Furthermore, again to our surprise, the response to IVT was in no way inferior to that following IAT, nor was there any increased tendency to pulmonary congestion or apparent heart failure when IVT was used at similar rapid rates of flow. This ability of hearts with healed infarcts to perform as normal ones can only lead to the assumption that a 3 to 4 cm. infarct is of little significance to a heart which possesses an otherwise normal coronary tree.

Our control animals with normal hearts responded equally well to resuscitation, following the Wiggers shock procedure, regardless of route of transfusion. Comparable rates of flow of about 5 cc. per kg. per minute were used. No difference could be established between the

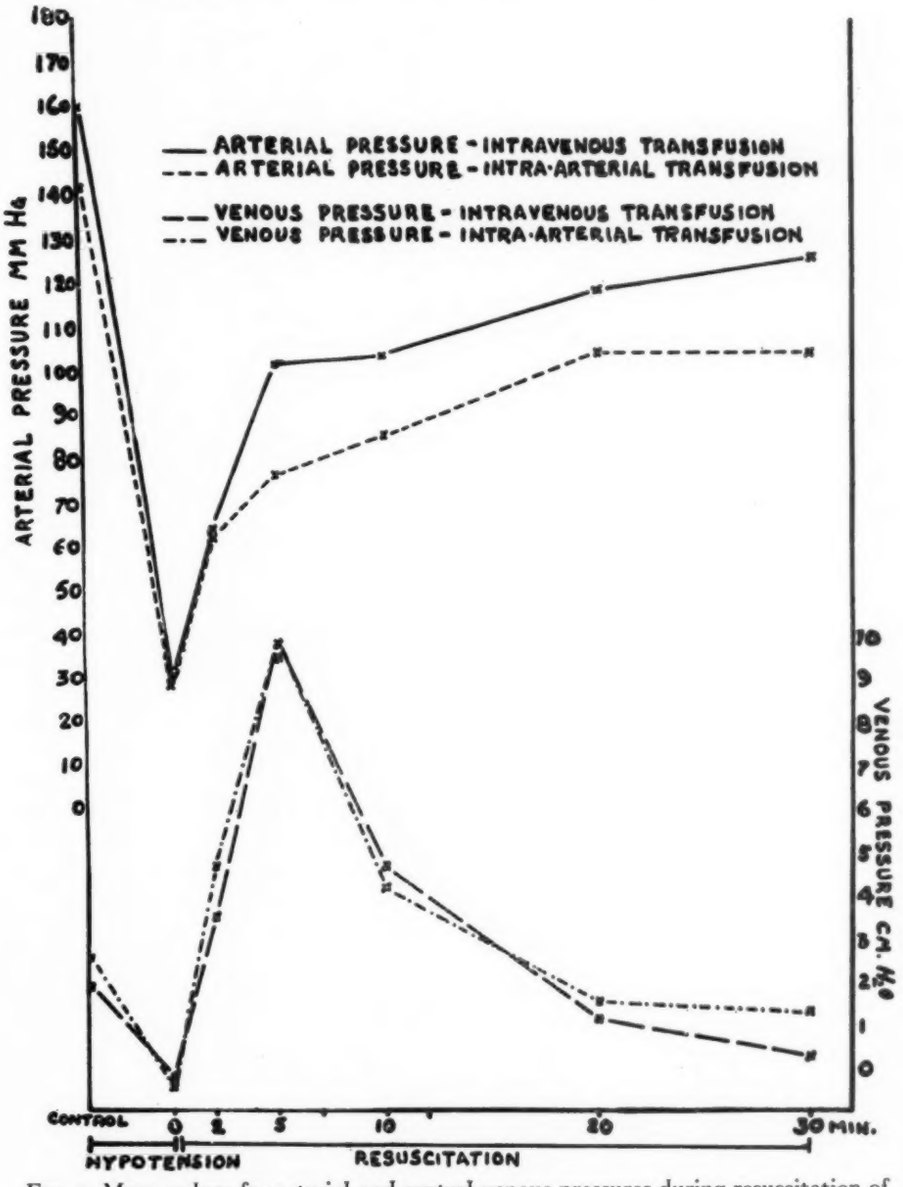

FIG. 2. Mean values for arterial and central venous pressures during resuscitation of animals with normal hearts. Hypotensive period was achieved by the shock procedure of Wiggers. Transfusions were administered at equal rates and no difference in response was observed between the two routes. Values are averages of six experiments in each group. (Courtesy of J. B. Lippincott Co. From Hampson, Scott and Gurd.[15])

response to IAT and IVT in terms of rate of recovery of blood pressure or ability to survive. (Fig. 2.)

During the course of this work we observed two points of practical importance which should be mentioned. First, it was unwise to replace rapidly more than 75 per cent of the previously shed blood for fear of inducing congestive heart failure. This applied equally to either route of replacement. Second, a warning of impending death during resuscitation was found to be inherent in a synchronous fall of the arterial blood pressure coupled with a rise of the central venous pressure. A rise of venous pressure always occurred in the first few minutes of rapid transfusion, but reverted rapidly to normal as arterial pressure rose. It was a secondary rise of venous pressure coupled with a secondary fall of arterial pressure which constituted the danger signal. This warning usually occurred as the point of 75 per cent of shed blood replacement was approached. It was not an agonal phenomenon. We came to recognize that this dangerous trend could be corrected by stopping the transfusion. The phenomenon occurred with equal regularity during IAT and IVT.

Dramatic responses to IVT have been reported before,[18,19] but have been overshadowed by striking instances of recovery by IAT such as the report of Hamilton, Drye, Kinnaird and McGowan.[20] In our opinion such controversy as has existed should now be considered closed. The facts would indicate that the treatment of hemorrhagic shock of the profound and dangerous type should consist in the introduction of blood into the circulation at any convenient point which will allow for a rapid rate of flow.

METHODS OF RAPID INTRAVENOUS TRANSFUSION

It is probable that the dissatisfaction with IVT which led to the enthusiasm for IAT rests in the fact that a large cannula in the radial artery will carry blood at a more rapid rate than will a needle in a small and spastic peripheral vein of the same individual. The radial artery, or even the aorta, have this point in their favor, and there may be times when their use is justified as routes for rapid infusion. However, the pumping systems described by Pierce, Robbins and Brunschwig,[18] and by Porter, Sanders and Lockwood[19] have given intravenous rates of flow up to 500 cc. per minute with notable results.

We would like to offer the suggestion, however, that the possibility of rapid IVT with ordinary hand-pump equipment be further explored. The principle of multiple streams, that is three or four transfusions under pressure simultaneously, is evidently advantageous. Direct puncture of the common femoral vein in the groin has restored patients when peripheral streams have failed. The external jugular vein is rarely collapsed, is usually accessible during operations and will take a large bore needle easily and safely. In the experience of the authors it has been a life-saving route for rapid transfusion on many occasions in both military and civilian practice.

SUMMARY

1. The role of the heart, lungs and coronary circulation in the classic picture of hemorrhagic shock has been re-examined briefly.

2. Recent data have been reviewed which appear to settle the controversy between the proponents of intra-arterial and intravenous transfusion.

3. The following practical points in the treatment of hemorrhagic shock have been emphasized: (*a*) Treatment of hemorrhagic shock of profound degree consists in the introduction of sufficient blood into the circulation at any convenient point which will permit of a rapid rate of flow. The side of the circulation into which the blood is transfused is of no importance provided that a rapid rate can be assured. (*b*) Overtransfusion by any route may defeat the resuscitative process if the normovolemic state is approached too rapidly after 75 per cent of the shed blood is replaced. (*c*) Warning of overtransfusion is signalled by a downward fall of the arterial blood pressure after a favorable rise, coupled with a simultaneous rise in the central venous pressure. (*d*) All available points for rapid intravenous transfusion, as alternatives to the smaller peripheral veins in common use, should be sought out and exploited.

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Observations on the Effects of Blood, Plasma and Sodium Salt Solutions in the Treatment of Extensive Burns

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THE fluid therapy of extensive full-thickness burns has been a subject for investigation and controversy for the past thirty years. Underhill[1] emphasized the fluid loss; Blalock[2] believed this to be primarily loss of plasma. On the other hand, Davidson[3] described a disturbance in sodium chloride metabolism. The therapeutic role of sodium in burned mice was discovered by Rosenthal[4] in numerous experiments which revealed the critical importance of an adequate volume of administered fluid. These factors were then explored in humans in preliminary clinical trials of the use of sodium salt solutions by Fox.[5] Whole blood was then combined with electrolyte solutions in burned dogs by Moyer,[6] and Abbott[7] utilized this combination in humans. McCarthy and Parkins[8a] and McCarthy[8b] in Ravdin's laboratory, investigated albumin, saline, dextrose in water and various combinations with blood, plasma and sodium lactate in burned rats. Based on observations in humans and dogs, Evans[9] proposed a formula combining blood, plasma or plasma extender, saline and dextrose in water.

In all of these investigations the experimental conditions, species of animal utilized, criteria of efficacy and basis for evaluation have been different. In most instances the investigators have not compared their studies with those of earlier investigators. When the obvious hazard of extrapolating results of animal experimentation to man is added, it becomes apparent that a solid foundation for prescribing a formula for the treatment of full-thickness extensive burns in man does not exist.

Accordingly, three years ago we attempted to organize a comparative study of the fluid therapy of burns in patients. After consultation with numerous experts it was decided to limit the study to comparison of two treatment schedules: the combination of blood, plasma or plasma extender, saline and dextrose in water versus sodium salt solutions only. The period of comparative study was to extend over the first three days from the time of injury; subsequently blood was to be used as liberally as required in both groups of patients in preparation for skin grafting. Patients were placed in each group on the basis of strict alternation. In both groups measurements of blood and urine composition were made at frequent intervals. The exposure method of local treatment was used wherever feasible in both groups. Patients were observed most carefully; had those receiving electrolyte only shown any need for blood and plasma, these were to be utilized.

The number of patients made available for this study was much smaller than anticipated; but the program has been continued and with the passage of time a larger and proportionately more valuable series of study cases will be achieved. Because of the limited number of patients it is essential to recognize the preliminary nature of this report and to understand that we are unable to draw any statistically valid conclusions at this time. We also conducted a detailed survey of approximately 140 patients with extensive burns, of whom 100 died. The combined clinical material raises many important questions which we present for your consideration.

It is apparent from our experiences and those of others that extensive full-thickness burns of more than 40 per cent of body surface area (BSA) are frequently fatal, and unfortunately many patients with less extensive burns

also succumb. As part of our program to improve therapy, experimental burns in mice and monkeys were studied. We would like to refer briefly to certain aspects of these investigations which have a bearing on problems of therapy.

One of the most important questions is how to gauge the amount of fluid therapy required as the extent of the burn increases. Evans and others have recognized clinically that as the area of burn increases beyond approximately 50 per cent BSA, the amount of fluid lost does not increase proportionately. To study this question, progressively increasing areas of body surface of mice were burned and the movement of sodium and water measured in treated and untreated animals. The identical burn was utilized: immersion of anesthetized mice into water at 7°C. for seven seconds.[4] The body surface areas immersed were one hind leg (7 per cent), two hind legs (14 per cent), both hind legs and trunk to axilla (60 per cent) and, finally, all the body except the head (80 per cent). In each animal the one hind leg was analyzed to determine the quantity of water and sodium acquired by this single region as the total area of burn increased. The viscera en masse were also analyzed to reveal the changes in the fluid and electrolyte content of essential organs such as heart, liver and kidneys.

Similar measurements were made in another group of mice treated with 150 cc. per kg. body weight of balanced 0.15 M sodium salt solution administered intraperitoneally approximately one-half hour after the burn. Tissue samples for analysis were taken approximately three hours after burning. (Table 1.)

With the minimal burn sodium and water in the hind leg increased greatly. As the total area of burn was extended, the hind leg acquired *less* water and sodium. Thus as the total burn approaches 80 per cent, the paradox of negligible shift of sodium and water appears. Likewise the viscera suffer maximal loss of sodium and water with the minimal burn. The apparent paradox is explained by recognizing that in the body there is a finite, limited quantity of sodium and water available for transfer from the unburned regions and viscera to injured regions. Transfer of this "available" sodium and water to one region (7 per cent burn) causes a large influx; but as the total body surface burned is increased, this "available" sodium and water is more widely dispersed and the influx into a given region is small. Furthermore, the more areas that are burned, the less regions there are to contribute fluid which can be transferred to the zone of injury.

TABLE 1
SODIUM AND WATER SHIFTS WITH INCREASING EXTENT OF BURN

Extent of Burn* Body Surface Area (%)	Hind Leg†		Viscera†	
	Sodium (mEq.)	Water (gm.)	Sodium (mEq.)	Water (gm.)
Mice Received No Fluid Therapy				
None	23	165	23	380
7	59	340	18	330
14	45	285	18	310
60	37	260	20	315
80	33	220	20	315
Mice Received 150 ml./kg. of 0.15 M Sodium Salt Solution‡				
None	23	175	26	385
7	65	445	27	440
14	56	355	23	355
60	45	270	23	365
80	36	225	25	360

* Extent of burn determined by area of body surface immersed (see text). Mice with burns under 60 per cent survive without therapy; designated therapy permits survival of most mice with 60 per cent burn but ineffective for mice with 80 per cent burn.

† For comparison, analyses of one hind leg tabulated in mEq. Na or gm. H_2O per 100 gm. fat free solids in the leg. Samples taken three hours after burn.

‡ Therapy given intraperitoneally thirty minutes after burn consisted of 0.15 M Na, 0.10 M Cl, 0.05 M HCO_3.

Inasmuch as the intensity of the burns is identical, the sodium and water acquiring potential of the injured tissues is similar. Failure of the more extensive burns to acquire equivalent sodium and water is attributable to limited availability resulting in unsatisfied demands. This is reflected in the results of the therapeutic experiment: administered sodium and water, and available endogenous sodium and water meet only the demands created by the minimal burns. Thus the minimal burn (7%) acquired more sodium and water, but with more extensive body surface area involvement,

progressively *less* sodium and water were transferred to the hind leg. In fact, even with treatment, the more extensive burns actually acquire less sodium and water than in the case of the minimal burn *without* therapy.

These studies make it clear that in mice the capacity of the burned tissues for sodium and water are but in small part satisfied by administration of 150 cc. per kg. when the total body surface area burned is more than 7 per cent. In this connection it should be pointed out that recent animal studies[10–12] show that therapeutically administered solutions move first to the zone of injury before expanding blood volume. Following thermal injury to tissues an avidity for sodium and water is created and sodium and water are siphoned from blood or plasma or sodium salt solutions, thereby robbing them of their ability to expand blood volume until these demands of burned tissues are fulfilled.

These experiments serve to indicate that the total amount of local edema seen in a patient early is not a measure of the amount of "fluid loss" which will ultimately occur; hence the fluid requirements should be based upon the volume of tissue injured, namely, both the depth and total surface area. Furthermore, it should be anticipated that swelling in and about the zone of injury will result from the thermal injury and not because sodium and water have been administered. These observations apply to burns which produce edema; burns resulting from longer exposure to higher temperatures cause far less shift of water and electrolyte.[13]

Practically all schedules of fluid therapy recommend glucose and water, or various dilute salt solutions to take care of large insensible losses of water and to provide water for urine formation. In view of the considerable data that fluid shifts in extensive burns are accompanied by equivalent or even greater shifts of sodium,[4,13,14] it seemed advisable to explore whether there is a need for water without sodium. Accordingly, mice were subjected to the standard burn[4] and treated with sodium salt solutions. Normal mice received the same fluid therapy. Both groups of mice were weighed at frequent intervals. Food and water were withheld from all animals for the eighteen-hour interval of the experiment. Similar measurements were made on untreated mice.

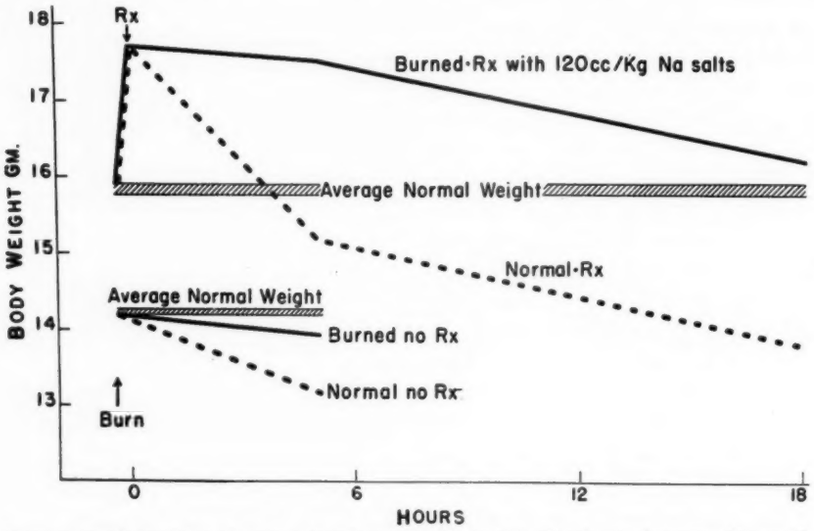

FIG. 1. Body weight change after burn shock and "effective" therapy. Normal animals exhibit considerable loss of weight indicative of insensible loss of water. Burned mice lose but little weight, hence exhibit minimal loss of water. A need for water without electrolyte is not demonstrable.

As may be seen in Figure 1, normal mice receiving fluid therapy showed an immediate increase in weight, with a subsequent rapid decrease to about 10 per cent below their initial weight. In contrast, burned mice increased in weight after fluid therapy but their weight remained elevated above the starting level. In untreated animals measurements were made only for six hours because most untreated mice died at this time. During this period normal mice lost considerable weight

but the burned mice lost little or no weight. In these experiments the weight loss was primarily loss of water with some destruction of body tissue due to starvation. The normal animals lost weight rapidly with or without fluid therapy, indicating considerable loss of water.

One of the recent changes in fluid therapy of extensive burns is the recommendation that large volumes of whole blood be administered promptly.[6] In the Evans formula[9] it is suggested that patients with extensive burns receive one-half of their colloid requirements as whole

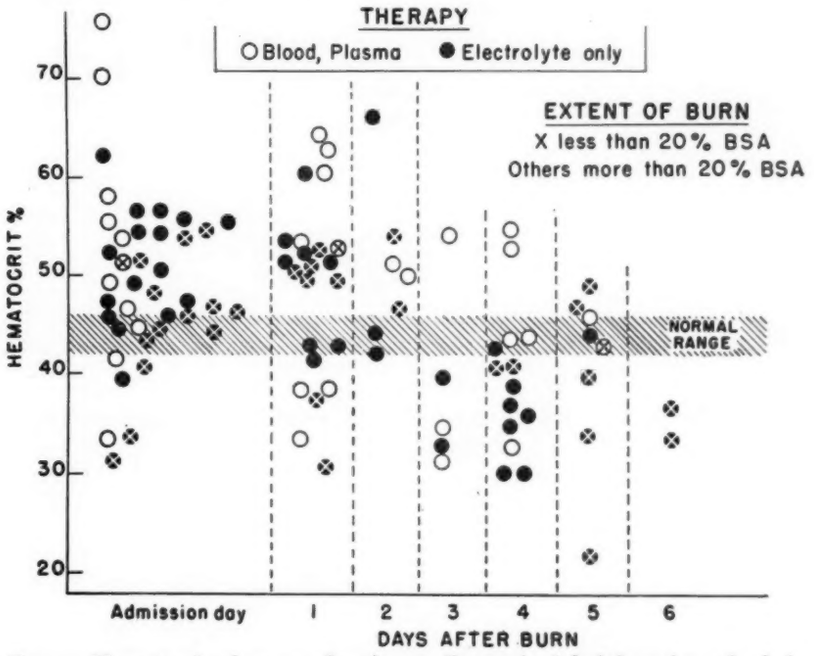

FIG. 2. Hematocrit changes after burns (human). Administration of whole blood and plasma did not invariably prevent development of subnormal hematocrit values.

In sharp contrast, the burned animals did not exhibit this metabolic loss of water. In fact, the oxygen consumption of mice in shock is greatly reduced and their body temperatures fall markedly.[16]

These data indicate that mice with their disproportionately larger body surface than man, after severe injury apparently require practically no water without sodium. It would appear that a need for water without electrolyte after thermal burns has not been demonstrated; the use of dextrose in water or water per os may contribute to the hyponatemia and overhydration frequently seen. Insufficient caloric intake also serves to decrease the water requirements.

Although our clinical studies of extensive burns do not permit us to set forth any formulas for treatment, there are a number of observations which may prove of value in suggesting the directions in which improvements are being sought, and these are summarized in the tables and figures which follow.

blood. It has been claimed that this modification will prevent the development of severe anemia in the later stages. By virtue of having two groups of patients, one receiving blood and one electrolyte solution only during the first seventy-two hours, it is possible to make comparisons of the changes in hematocrit or red cell volume. (There are not enough cases in our series to warrant any conclusions as to the efficacy of whole blood in combating shock.)

Figure 2 shows distribution of hematocrit determinations made on admission and at varying times thereafter. Some patients with extensive burns have hematocrits ranging up to 77 per cent. As the therapy progresses, despite the administration of massive quantities of whole blood, subnormal values occurred in some patients in this small series. In other patients with extensive burns receiving no blood marked decreases in hematocrit did not develop. In some patients with moderate or mild burns, with high initial hematocrit values, the hematocrit remained above normal for

many days. It is significant that experimental studies of red cells tagged with chromium-51 do not disclose an extensive destruction of red cells.[17] Furthermore, our preliminary experiments in monkeys suggest that after an extensive burn the red cell mass does not change

tions of the plasma electrolyte changes in these patients. The results in twelve of the most extensively burned patients are shown in Figure 3. Similar changes were found in the other patients. On admission, or shortly thereafter, with great consistency, the plasma

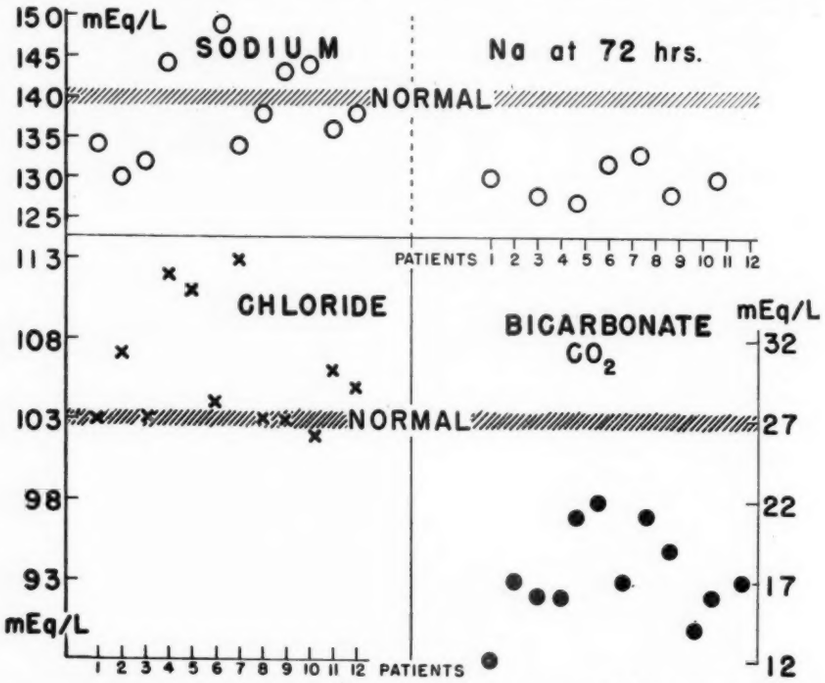

FIG. 3. Plasma electrolytes in patients with severe burns. Values on admission before therapy show hyperchloremic acidosis; sodium values scattered. At seventy-two hours all sodium values subnormal despite large sodium intakes.

although the plasma volume increases, thereby resulting in reduction in hematocrit. It is generally known, although frequently not appreciated, that the hematocrit measures only the percentage of red cells in a given sample of blood; thus it provides no indication as to the volume of red cells in the patients' circulatory system. This can be measured by the use of chromium-51 labeled red cells, which actually determine the circulating red cell volume.[10] Thus a low hematocrit may result from the combination of an increased plasma volume and a normal red cell volume; transfusions of whole blood to correct this type of "anemia" might be inadvisable. It would appear that whole blood keeps the hematocrit in less severe burns above normal but does not prevent the hematocrit of patients with extensive burns from falling below normal.

In view of the significant electrolyte changes which occur in burned[13] and traumatized tissues[18] it seemed important to make observa-

chlorides are elevated and the plasma bicarbonate reduced. Measurements of pH are essential, but these values combined with the increase in rate and depth of respiration indicate the development of acidosis and hyperchloremia. The sodium levels on admission are scattered: some high, some low, some normal. In all patients, regardless of therapy, the plasma sodium decreased below normal by seventy-two hours, remaining low in many patients for ten days.

With these changes in mind, certain suggestions might be advisable regarding the electrolyte composition of therapeutic fluids which are compared in Table II. The administration of fluids high in chloride and without bicarbonate as 0.9 per cent sodium chloride, accentuate the elevation in chloride and reduction in bicarbonate.[19] Inasmuch as the treatment of extensive burns in accordance with any formula requires administration of large volumes of sodium-containing solutions, saline should

be substituted by a solution with some of the sodium chloride replaced by sodium bicarbonate (or acetate or lactate), e.g., NaCl—6 gm. plus $NaHCO_3$ or acetate, 4 gm. It is not always appreciated that plasma obtained from the blood bank contains sodium citrate which raises the sodium and lowers the chloride concentration. In contrast, when 6 per cent dextran in 0.9 per cent saline is substituted, the patient receives no sodium citrate to help combat acidosis but does receive far more chloride than when plasma is administered. This would appear undesirable in view of the initial hyperchloremia; if dextran is to be used as a plasma extender, it would seem reasonable to prepare it in a plasma-like solution.

TABLE II

ELECTROLYTE COMPOSITION OF FLUIDS USED IN TREATMENT OF EXTENSIVE BURNS

	Na	Cl	HCO_3	K	Ca	Mg
	(mEq./L.)					
Average normal plasma*	140	103	27	5	5	3
Plasma obtained from citrated blood	190	80	90†	4	†	†
6% dextran in saline	154	154	0	0	0	0
6% dextran in balanced electrolyte solution	140	103	55‡	10	5	3
0.9% sodium chloride	154	154	0	0	0	0
Ringer's lactate (Hartman's USP)	130	109	28§	4	3	0
Balanced electrolyte solution (Fox et al.[19])	140	103	55‡	10	5	3

* Average values found in normal humans (from Gamble).

† Sodium citrate used as anticoagulant is ultimately oxidized in body to bicarbonate; both Ca and Mg are bound and unionized until citrate is metabolized.

‡ Denotes acetate 47 plus citrate 8 rapidly converted to bicarbonate by metabolism in body.

§ Denotes amount of lactate converted to bicarbonate by metabolism in body.

Acidosis is one of the most frequent serious electrolyte abnormalities. Specific, detailed instructions for its correction are included in The National Research Council recommendations.[2] Numerous observers[5,7,8,20,21] have reported that increased urine output is obtained when acidosis is corrected with sodium lactate, acetate or bicarbonate.

The consistent reduction in sodium is another signal that dextrose in water is contraindicated because it further lowers electrolyte values and contributes to water intoxication.

The plasma potassium levels are also of interest. Normal or sub-normal values were found on admission in most patients, although rarely values between 5.0 and 7.0 mEq./L. were found. Subsequently these values scattered throughout the range of normal to subnormal (3.0–3.5). Although potassium toxicity may be a factor in massive burns with sudden death occurring in minutes, in our experience plasma values tend to be low similar to the recent experimental observations of Amspacher.[22] In an effort to explore the over-all metabolism of potassium, the excretion of this cation in the urine of these patients was reviewed. The results were summarized in Table III.

The values for daily excretion are categorized arbitrarily as low, normal or high, and serve to indicate the direction of the observations. During the first forty-eight hours after the burn, urine potassium was high in ten samples, five occurring in patients who died during the first week. The others were normal or low. During the third to fifth day the potassium excretion tended to decrease, in some patients falling

below 10 or 20 mEq. per day. In some of these instances excretion increased toward normal but in a larger number of patients subnormal values continued. The intake of potassium is practically nil during the first few days, hence "normal" excretion might be considered

TABLE III
POTASSIUM EXCRETION IN URINE AFTER BURNS

Excretion for 24-Hr. Period (mEq.)	Days After Burn*		
	1–2	3–5	6–10
6–37 (low)	6	23	33
38–75 (normal)	13	16	17
Over 75 (high)	10	4	6

* Figures indicate number of patients in each group.

"excessive." During the subsequent days the intake of potassium is increased as the patient takes food; the finding of low values during this period (three to ten days) might be considered a manifestation of potassium conservation.

These low excretion values have to be reconciled with the occurrence of events usually followed by urinary loss of potassium from the body: tissue trauma, adrenocortical stimulation, infusion of sodium salts, acidosis and sodium retention. All of these occur in varying degrees in patients with extensive burns; nevertheless, there is little evidence of increased potassium excretion. In contrast, there seems to be evidence of subnormal potassium excretion, which might be interpreted as an indication for administration of potassium. The combination of hypopotassemia and the tendency of solutions devoid of potassium to dilute extracellular potassium levels, might suggest the desirability of including at least the normal plasma level of potassium in solutions administered therapeutically. For example, plasma contains potassium, but dextran in saline does not. Should not this element be included in preparing a synthetic plasma extender? The 6 per cent dextran administered to patients in this study was prepared in a solution* which contained 10 mEq./L. of potassium. (Table II.)

* We are indebted to Dr. Walter E. Ward, medical director of the Cutter Laboratories for providing generous supplies of this solution and the balanced electrolyte solution, polysal®, for our investigations.

No evidence of potassium toxicity was found clinically or analytically.

In attempting to assess the value of various regimens such as those recommended by Abbott,[7] Harkins,[20] Evans[9] and Cope and Moore,[21] and associates, it may be helpful to review the fluid therapy of patients in our series. As in any clinical study, the patients differed in age, sex, weight and general physical conditions. More important perhaps are the differences in the burns themselves, in their location, depth and area. Evans[9] has attempted to standardize therapy by expressing fluid in terms of ml. per kg. of body weight per cent burned. One ml. of plasma or plasma substitute and a like amount of saline is recommended. If the burn is very extensive or chiefly full-thickness, 0.5 ml. of whole blood is advocated in place of this amount of plasma. In addition, approximately 2,000 ml. of 5 per cent dextrose in water is recommended for adults.

In our study in order to minimize confusion all patients with mild burns as classified by Abbott[7] were omitted. The group being reviewed sustained predominantly full-thickness burns. (Patients with almost total body burns dying shortly after admission before major therapy had been completed were omitted from this study.)

For the purpose of reviewing therapy, the patients were divided into three groups: (1) patients who died during the first week; (2) patients who died seven to twenty weeks after injury (cardiac arrest during skin grafting, etc); and (3) patients who had successful skin grafts after periods of hospitalization in excess of ten weeks. The children in this latter group are listed separately. The burn is expressed as the product of the patient's weight in kilograms multiplied by the per cent of body surface of deep second and third degree burn. Thus a patient weighing 50 kg. having a 20 per cent burn is said to represent 50×20 or 1,000 burn units.

The fluid therapy given during the first seventy-two-hour period of active therapy is totaled excluding infusions of dextrose in water and water given by mouth. The patients on the electrolyte regimen did not receive dextrose in water. The volume of blood, plasma, dextran or sodium salt solutions were totaled directly. The total volume of fluid was then divided by the number of burn units to give the figure designated "ml. per kg. per per cent burn."

In the Evans formula this figure is 1 ml. of blood or plasma, and 1 ml. of saline in the first twenty-four-hour period, and one-half this amount in the second twenty-four-hour period; thus the total ml. per kg. per per cent of body surface burn is: $1 + 1 + \frac{1}{2} + \frac{1}{2} = 3.0$. For the purpose of comparison, the data of twenty patients are compressed into Table IV; the values for extent of burn and volume of therapy are averaged.

TABLE IV
SUMMARY OF FLUID THERAPY OF EXTENSIVE BURNS

No. of Patients	Day of Death	Burn* (% BSA × wt.)	Bl-Pl-Dx-Na† (cc./kg./burn %)
4	1½–7	2,000	5
3 (1 child)	54, 80, 150	2,400	6
Survived and Grafted Successfully			
8	.....	1,500	7
5 children	.....	600	11

* Per cent body surface area of deep second and full-thickness burn times weight in kg.

† Volumes of blood + plasma + dextran + saline or electrolyte solution only per kg. body weight per per cent burn. D/W or H_2O not counted.

The patients with extensive burns who died in the first week averaged 5 ml. per kg. per per cent burn. The patients who died from fifty-four days to three months later, averaged 6 ml. per kg. per per cent body area burned. The burn involvement averaged 33 per cent and 40 per cent, respectively, in patients weighing 60 kg. In the eight adults who were successfully grafted, the therapy was 7 ml. per kg. per per cent burned. In five children with average burns of the magnitude of 30 per cent in subjects weighing 20 kg., the fluid therapy was 11 ml. It may be significant that the volume of therapy was greater in the patients who survived beyond the first week (period of burn shock) than in those who succumbed. One patient who died on the fifty-fourth day was so extensively burned that skin grafting was not attempted.

The volume of fluid administered to these patients was from two to four times that recommended by Evans,[9] and not greatly different from the volume previously recommended by The National Research Council[20] and by Abbott.[7] Noteworthy is the fact that these patients received two to five times more electrolyte solution than colloid, whereas the Evans formula specified equal amounts of colloid and saline. In Evans' report[9] the therapy of the patients who survived differed from his proposed formula in two respects: they received considerably more saline than plasma and a greater total volume.

TABLE V
ANALYSIS OF THERAPY OF 100 PATIENTS WITH EXTENSIVE BURNS WHO DIED (1951–1952)

Amount Administered in First 10 to 47 Hr. After Injury (L.)	Type of Therapy Utilized	
	Blood, Plasma D/W, Saline	Sodium Salt Solutions Predominantly (no colloid)
	(% of patients in each group)	
Less than 1	19	18
1–3	40	41
3–5	22	41
Over 5	19	

Our studies do not include a sufficient number of patients to warrant any inference as to the relative efficacy of the regimen utilizing blood and colloid compared with the use of electrolyte solutions only. At the moment, the evidence seems to be in the direction of the need for greater total volume. The fact is clear, however, that patients with extensive burns responded well to treatment with electrolyte solutions only and recovered.

Further evidence as to the total volume of fluid apparently needed was sought by analyzing the clinical records of 100 patients who died during 1952. (Table v.) Some received blood and plasma and some received electrolyte solutions only. Table v indicates their survival in relation to the amount of therapy each received. In general those who lived longer received more therapy. This was not unexpected. It can be seen, however, that in this group the addition of blood and plasma did not appear to alter the length of survival. The fact must be faced squarely and that is that many patients receiving electrolyte solution only

recovered. The final answer is not now available.

In planning therapy it seems necessary to ascertain how much additional therapy is required by the more extensively burned patients who seem to die despite the best efforts of all. It is unequivocal that many of the patients with extensive burns die after having received proportionately less fluid therapy (6 ml. per per cent burn) than other patients with lesser burns who recover. When relatively large volumes of sodium-containing fluid apparently are required by less extensively burned patients who recover, it is difficult to see why less is administered to more extensively burned patients who fail to recover. Furthermore, in view of the extensive use of the Evans type formula, it should be recognized that the total fluid recommended (colloid plus saline plus dextrose in water) is hypotonic; in addition, as blood is substituted for plasma, the total amount of sodium administered is further decreased.

SUMMARY AND CONCLUSIONS

We recognize that much remains to be done and we hope that our experimental investigations of thermal burns in monkeys, together with continuation of the alternate case study of patients, will enhance our knowledge. In the meanwhile the data presented would seem to warrant these suggestions for improvement.

Early Therapy

1. Attempt to normalize the blood and plasma volumes: a prerequisite to this objective is measurement of both the red cell volume with chromium-51 and the plasma volume with I-131 labeled albumin, as described in the study of surgical trauma.[10] Replacement of extracellular fluid is essential for establishment and maintenance of a normal blood volume. These accomplishments require adequate provision for the large losses in the injured tissues before and during therapy.

2. Measure repeatedly in plasma and urine the concentrations of Na, K, HCO_3, Cl and direct therapy toward bringing these values to normal.

3. Fluid therapy might well be altered in the direction of increasing the total volume of isotonic solutions, whether or not they contain colloid, to 150 ml. per kg. body weight within first twelve to twenty-four hours to patients with extensive burns. A considerable portion of this is to be rapidly administered intravenously during the first ten hours; subcutaneous, intramuscular or intraperitoneal routes can also be utilized to be certain of absorption. Acidosis which is always present in patients with extensive burns should be corrected promptly as previously recommended.[5,20]

4. The proportions of electrolytes in the solutions used should be changed so that electrolyte concentrations similar to plasma or extracellular fluid are utilized. This becomes especially important when large volumes are to be administered. A few pints of saline will scarcely alter plasma composition, but 5 to 10 L. of saline and dextran in saline will significantly raise plasma chloride and lower bicarbonate. In addition, it might seem reasonable to include in plasma extenders and in electrolyte solutions, the other positive ions of plasma, including potassium.

Late Therapy

5. In the days that follow initial therapy the tendency for sodium and bicarbonate levels to fall and potassium excretion to diminish might be overcome advantageously by the administration of potassium and sodium acetate or bicarbonate (5 to 10 gm. of each daily to adults). Plasma and urine electrolyte analyses may serve as useful guides.

6. After the initial fluid therapy has been completed, whole blood transfusions should be administered as frequently as required, based upon accurate measurements of red cell volume and plasma volume, remembering that the hematocrit may be misleading because it is a true index of circulating red cell volume only when plasma volume is constant.

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The Hazard of Transfusion in Patients with Chronic Anemia

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SURGEONS are confronted from time to time with the problem of performing major emergency operations on patients with chronic anemia. When a patient presents himself with a serious fracture or other accidental trauma requiring operation and is found to have severe anemia, the first impulse is to raise the hemoglobin level rapidly by the transfusion of blood to prepare the patient for operation as soon as possible. This has been our practice in the past. We have recently had two patients with chronic anemia in whom pulmonary edema developed after transfusions which would ordinarily not have been excessive. Because of this experience our attention was drawn to some physiologic studies of Sharpey-Schafer and others[3–6] which point out the hazard involved in such practice. We therefore reviewed the clinical records at the Mary Imogene Bassett Hospital of patients with pulmonary edema and were able to find four cases in which the condition had apparently been precipitated by the infusion of blood. In each of these patients chronic anemia was present and in none was there evidence of serious heart disease before the transfusion was given. There was no record of pulmonary edema being precipitated by intravenous infusion in the absence of serious cardiac disease when the hemoglobin was normal or when anemia was the result of acute blood loss. The youngest patient was four years old and the oldest eighty-six. The initial hemoglobin levels were 1.8, 4.4, 8.3 and 10 gm. per 100 ml., respectively. In one instance pulmonary edema was noticed after 400 ml. had been given in two and one-half hours, in another after 500 ml. had been given in two hours, in another after 500 ml. had been given in three hours, and in the fourth after 1,500 ml. had been given over a period of seventeen hours. Two of the patients died in pulmonary edema, and the other two recovered and were later able to receive blood given more cautiously.

COMMENTS

Although I have done no original work on this subject, I feel justified in calling attention to the important contributions of Sharpey-Schafer and others—contributions which have not been given the publicity they deserve in the surgical literature.

The problem is why are patients with chronic anemia more liable than normal individuals to develop cardiac failure following rapid transfusion of blood. Since reading Sharpey-Schafer's published reports, I have discussed this matter with physiologists. As a result I am bewildered by the complexities of the mechanisms governing the control of the circulation. As I understand it, the problem can be simplified in the manner originally presented by Sharpey-Schafer.[4] To understand his explanation one must refer to Starling's "law of the heart."[1,2] This law can be expressed as the relation between atrial pressure and cardiac output as is shown in Figure 1. For a constant heart rate and constant chemical conditions, rise in atrial pressure results in greater cardiac output. This intrinsic property extends over a physiologic range beyond which further increase in pressure is associated with a fall in output. This inflection in the response curve constitutes one definition of the term cardiac failure. It must be re-emphasized that this curve applies only to constant heart rate and constant chemical conditions.

Sharpey-Schafer has demonstrated the same pressure-output relation in the heart of normal subjects when the right atrial pressure is increased by rapid infusion. This is demonstrated in Figure 2. He has also shown that the presence of chronic anemia imposes on an otherwise normal heart a change in the pressure-output

relation as shown in Figure 3. The important thing to notice is that the anemic heart starts with a relatively higher atrial pressure and relatively greater output in the resting condition. In other words at rest the anemic heart lies near the peak of its curve and in these

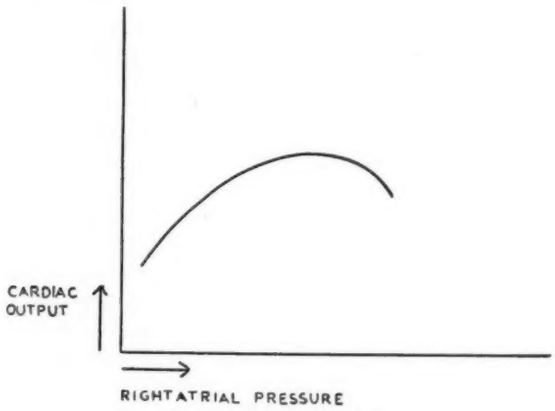

FIG. 1. Starling's law.

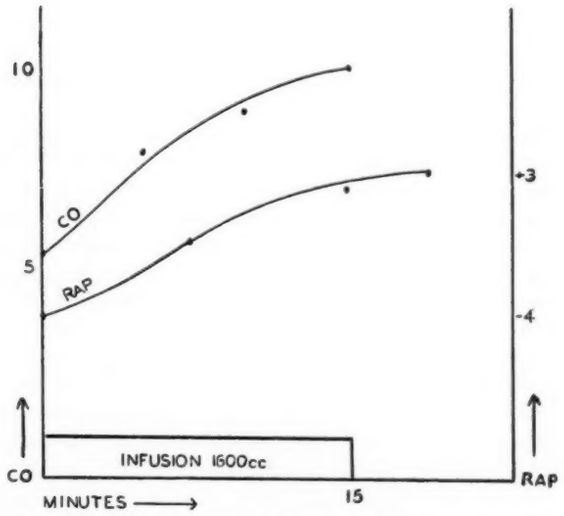

FIG. 2. Relationship of right atrial pressure to cardiac output in normal subject (after Sharpey-Schafer). Cardiac output is expressed in liters per minute, and atrial pressure in centimeters of water.

terms is on the verge of failure, so that any further increase in filling pressure, such as might be imposed by rapid transfusion, may result in a fall in cardiac output, or heart failure. It must again be emphasized that this response applies only to conditions of constant rate, constant nervous stimulation and constant chemical environment so that direct application to a clinical situation is impossible. Nevertheless, it should serve as a warning to surgeons and is a useful guide to rational replacement therapy.

In essence, recognition of these phenomena should result in the same attitude of caution in respect to blood transfusion in the presence of chronic anemia as one has to intravenous

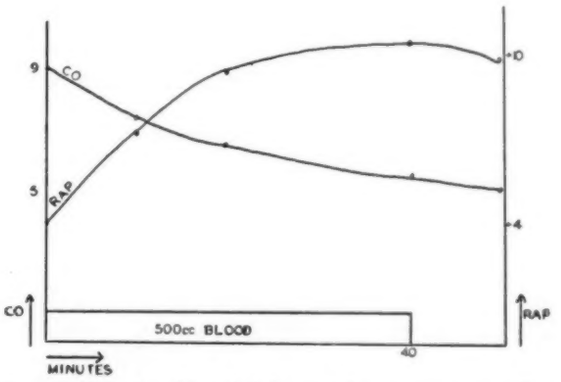

FIG. 3. Relationship of right atrial pressure to cardiac output in anemic subject (after Sharpey-Schafer). Cardiac output is expressed in liters per minute and atrial pressure in centimeters of water.

infusion in a patient with obvious signs of congestive cardiac failure.

With these physiologic observations in mind we are now observing certain precautions in preparing an anemic patient for operation. These are: (1) When it is possible, operation should be postponed for several days until the hemoglobin level can be raised slowly. We believe that transfusion at the rate of 250 ml. per day is safe; but that if more rapid restoration is necessary, it should not be carried out at a rate more rapid than 250 ml. in any twelve-hour period. Packed erythrocytes are usually more suitable than whole blood. It is self-evident that any continuing blood loss must be stopped or replaced as it occurs. (2) During the course of transfusion, the patient should be in a semi-sitting position because it has been demonstrated that in this position the right atrial pressure is lowest.[3] (3) If there are signs of heart disease, rapid digitalization may be of value. (4) If signs of pulmonary edema appear, transfusion must be stopped and other measures, such as phlebotomy or the application of venous tourniquets to the extremities, taken as indicated.

Although we have not been putting these precautions into practice for a long enough time for me to be able to report a change in our mortality rate, we have confidence in their

applicability and so pass the information on for consideration.

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DISCUSSION OF PAPERS BY DRS. RAVDIN AND CASBERG, GURD AND GARDNER, WINFIELD, MERSHEIMER, FOX, SILVERSTEIN AND LASKER, AND MITHOEFER

James M. Winfield (closing): The only thing I can say is that most of these papers show the complexity of this subject, and possibly partially add to the general confusion. However, there are certain points that I think we all have realized are of importance.

I do believe that some of the work that seems to be coming up from our particular projects would indicate what has already been said by Dr. Fox, that is, in giving colloid solutions we should not forget that electrolytes might possibly be something which should be added. After all, when giving blood which is a colloid, electrolytes are present.

We believe that we may be getting somewhere with our studies in monkeys who are much more analogous to man in their reactions to insult, trauma, burns and otherwise. A monkey, too, can be a controlled subject. You know his blood volumes and his status before he is burned; whereas, of course, with a human being, you are unable to determine those factors before you receive the individual with the injury.

Robert H. Kennedy (New York, N. Y.): Dr. Ravdin and Dr. Casberg presented to us the figures in recent wars comparative with a 2 per cent death rate in the Korean affair. I think you would all agree that similar casualties in this country, in civilian life today, if they happened right now, would show a tremendously higher percentage of deaths, even though they would occur much nearer the hospital than was the case in Korea. I think what we all have to face is that at the present time we are not doing the job in civilian life of saving such severe casualties; but as we've learned from the Korean affair, it is perfectly possible to solve this problem and armed with our present knowledge we should be able to accomplish much if we are set up to do it.

Thomas Bartlett Quigley (Boston, Mass.): I should like to make a point and ask a question. The point was touched upon by Dr. Ravdin, and also by Dr. Mithoefer in their excellent papers, and that is that in military practice good general health is assumed and usually is present before injury. This is certainly *not* the case in civilian practice.

Recently a senior medical student I analyzed was among forty consecutive injuries in civilians admitted to the Peter Bent Brigham Hospital for the treatment of injury. Of these, eighteen had significant concomitant disease of which they were not aware, including hypertension, gastrointestinal tumors, diabetes and the chronic anemia of which we've heard. This is something we must remember.

The question I would like to ask Dr. Mithoefer is this: What about the patient for whom surgery is really urgent and who has chronic anemia? Would you not consider the use of packed red cells? We have found this useful in this situation.

I. S. Ravdin (closing): I would like to raise a question with Dr. Mithoefer as to what they would do at Cooperstown if they had a patient they were preparing for major operative procedure who had very severe anemia. I am thinking of the type of patient, for instance, who has chronic anemia associated with a lesion of the cecum or the first portion of the ascending colon. We have rapidly transfused those patients. We have never seen an instance of pulmonary edema. The whole period of preparation takes at most four to five days, during which time we attempt to obtain as fully as possible a clean and an empty bowel, and to use antibiotic therapy for its effectiveness against the intestinal organisms.

We have such a patient now, a gentleman in his upper sixties, with a hemoglobin of 40 to begin with; this is a usual occurrence with us.

I wonder whether the chronic anemia itself was the major factor in the production of the unsatisfactory result which they have had in several patients.

I should also like to say a word about intra-arterial and intravenous transfusions. I think the time has come when this Association might let that dog lie dead for the rest of its life. I think Dr. Gurd has added evidence to that already presented, and I had hoped he would mention a word of Fitzpatrick at the Presbyterian Hospital in New York, who had quite a debate in New York several years ago with one of the proponents of the intra-arterial method of transfusion.

In my estimation there is not one iota of evidence which will point to the fact that an intra-arterial transfusion is any more effective than an

intravenous transfusion in which the same amount of blood is given in the same period of time. This is a question of mass and period of time of injection.

Furthermore, I want to call attention to the really serious hazards involved. We have had three instances of peripheral gangrene of the upper extremities associated with intra-arterial transfusions and many others have reported such instances.

Dr. Quigley has rightly raised the point that in the mortality that I reported incident to the recent adventure in Korea, one must take into account the fact that you are dealing with young men who are essentially normal individuals from the standpoint of health. If you have been on duty at all, you know that these youngsters are not in good health, and you ship back diabetics and other individuals from overseas. Most of them are in good health. But a mortality rate of 2 per cent of those wounded in action, under conditions which should also be considered against the state of health, is really a remarkable result, and I agree with Dr. Kennedy that if we had mass catastrophes, as we had in the Texas City disaster, Worcester and other places, the mortality rate would be higher than that which occurred in the Korean incident, where you had adequate numbers of well trained young surgeons, thoroughly indoctrinated in the care of mass casualties. We shall never attain a low mortality in civilian life among mass casualties unless all those who participate in the care of these individuals are equally well indoctrinated and to that extent our Civil Defense program in this country has fallen down very badly.

Finally, I should like to say one word, because I believe this Association has a very important mission in the care of trauma in this country. One of the most important problems that faces us now is to develop methods of preserving blood over long periods of time. It makes no difference whether we collect a million units of blood in the United States or less, we keep that blood for only three weeks. Then we have only its plasma available which we cannot now use because we have no effective way of sterilizing plasma, except the method of Garrett Allen of Boston. I personally believe this is an effective method, but there are many of those in and outside of the Government who have not been so convinced.

However, even plasma itself does not take the place of blood, and we must develop methods whereby large amounts of blood can be stockpiled, whether this be blood as blood, or whether it be red cell masses that are kept, as Dr. Quigley spoke about, because I believe that is a very important item.

We have two methods now available, where, within a short time, we might achieve this. First, in the freezing of red cells, a method first initiated by Mollison in England, and now being carried on by Dr. Slovin of my staff. Red cells have been frozen for periods of ten months, human red cells that you had, and introduced in man living a normal life span. This was done in a pilot type of experiment. We must devise some method whereby this can be done in mass projects.

Secondly, the type of work being done by the investigators at the University of Washington in Seattle, by Finch and others, where, with chemical agents such as a triphosphate solution added to blood, one can greatly prolong the effectiveness of the life of the red cell.

Between these two methods, one a thermal or freezing method and the other a chemical method which affects the metabolic activities of the cell—in fact the freezing method does this too—we can, if sufficient resources become available for pushing this type of work, develop a method whereby in the period of a year, perhaps less, we shall be able to provide over long periods of time large amounts of blood.

CHARLES L. FOX, JR. (closing): I think we have learned a great deal from the presentations concerning hemorrhage and the experience in Korea. I would just like to suggest that it may not be entirely accurate to apply the knowledge of trauma to the problem and management of extensive burns in the direction of the use of massive whole blood transfusions.

We certainly don't know what the final answer is, but I think we ought to keep alert to developments which are going on in this area, such as, for example, the work of Raker and Rovitt in Boston, who studied the destruction of red cells during severe burns and found that the destruction of red cells was far less than had been anticipated in extensive burns (*Surg., Gynec. & Obst.*). Although the mortality from extensive burns is still fairly high, the evidence is not yet at hand that larger transfusions given more rapidly or more numerously will improve the mortality rates.

I think, again, we are in an area in which research will bring forth an answer, and I hope that other groups will conduct investigations in which some alternate case procedure will be followed, and that we can gather figures from a variety of clinics to help find the right answer to this extremely difficult problem.

JAMES MITHOEFER (closing): Dr. Quigley, we have used packed red cells and have found them to be very effective.

I hope that I have not left the impression that I don't favor giving transfusions to people who are anemic and that I don't favor operating upon them when it is necessary.

When confronted with a patient with chronic anemia (as opposed to anemia due to acute blood loss) who requires an operation, one must then

take the calculated risk of determining which is more dangerous: transfusing that patient rapidly or delaying operation.

One must realize that the anemic patient with an otherwise normal heart, but with chronic anemia, is closer to heart failure and to the development of pulmonary edema than he would otherwise be, and one must therefore transfuse him with utmost caution.

MELVIN A. CASBERG (closing): I should like to comment on the applicability of patient evacuation and patient hospitalization to Civil Defense. As a member of the Governor's Medical Advisory Committee to the State Disaster Council of California I have been perturbed on occasion at the slowness with which information which has been available through experience in the Armed Forces is being applied by local planners to the problems of Civil Defense.

I realize that in Civil Defense there is not a central or federal control as is the case in the Armed Forces, but rather authority is delegated peripherally to individual areas. Nevertheless, when we speak of Mobile Army Surgical Hospitals or their equivalents being purchased by Civil Defense funds and then set down more or less permanently in specific fixed places to be operated in an immobile manner in the event of major catastrophe, it seems that we are asking for trouble. In other words, in Civil Defense, it seems to me that we might learn from experience gained by the Armed Forces and that is to have hospital units which can be moved, mobile units, which can be distributed as the geographic needs arise.

As an example let me refer to an Air Force evacuation hospital which was broken down when I gave the signal one morning here in the East and that evening this same hospital was set up and served the evening meal in Texas over 1,000 miles away.

The mobility of our hospital units not predesignated geographically, but units which can be moved, is of fundamental importance to Civil Defense.

Bile Duct Rupture from External Blunt Trauma

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TRAUMATIC rupture of the biliary duct system is a rare complication of closed abdominal injuries. Rudberg[1] reviewed the literature in 1921 and was able to collect forty-one cases. In 1938 Lewis[2] collected six additional cases from the literature and added one of his own. Lysaght,[3] in 1939, reported the case of complete severence of the common duct in a man crushed between a steel rafter and a pile of steel girders, and in 1948, Hicken and Stevenson[4] presented an unusual case of laceration of the common bile duct associated with acute traumatic pancreatitis in a seven year old child who had been crushed by a tractor. Recently, Mason et al.[5] reported two cases of similar injuries in infants.

CASE REPORTS

A fifty year old white male farm hand (H. P. File No. 44516-A) was admitted to the surgical service of the Edward J. Meyer Memorial Hospital on October 31, 1950. He stated that he had been hit in the abdomen by a bull approximately six hours previously and complained of severe diffuse abdominal pain and of marked thirst. Past history was non-contributory.

Physical examination revealed a well developed white man, quite dirty, who had a distinct alcoholic odor to the breath. Head, eyes, ears, nose and throat were normal. There was a small contusion of the left anterior chest wall in the fifth interspace just lateral to the sternum, and a small abrasion of the left posterior chest wall at the level of the eighth rib.

The abdomen showed diffuse tenderness without localization, as well as diffuse muscle guarding. Tenderness was also noted over the right eleventh and twelfth ribs posteriorly. Peristalsis was active. Liver dullness was present. There was a right reducible scrotal hernia. Blood pressure was 130/80, pulse 96.

Initial laboratory studies revealed the following: Hemoglobin 11.0 gm., red blood count 3,800,000, white blood count 25,500. Urinalysis was normal except for many red cells in the sediment.

A working diagnosis of contusion of the right kidney was made, and the patient was admitted for observation for possible ruptured intra-abdominal viscus. Scout films of the abdomen on the following day showed the stomach markedly distended with gas. He was treated conservatively with gastric suction, penicillin and parenteral fluids.

Repeat abdominal films on the second hospital day showed dilatation of the large bowel and generalized haziness suggesting the presence of fluid. Streptomycin was added to the antibiotic regimen at this time. A urologic consultation was requested, and intravenous pyelograms showed normal-functioning kidneys. It was the opinion of the urologist that we were dealing with a contused kidney with secondary paralytic ileus.

Supportive treatment was continued. A slight yellow tinge of the sclerae and skin was noted on the fifth hospital day. The skin became increasingly icteric along with progressive abdominal distention. Peritoneal tap on the tenth hospital day yielded green-yellow bile. The patient was operated upon the same day.

At surgery a right paramedian incision was made. The peritoneal cavity was flooded with bile, and approximately 3 L. were aspirated. All of the viscera were deeply bile-stained. Careful examination of the liver, gallbladder, cystic and common ducts, and duodenum revealed them to be normal and intact. Further inspection showed the source of bile leakage to be a longitudinal rent in the right hepatic duct, approximately 0.5 cm long, on the anterior wall of the duct just beyond its emergence from the liver. (Fig. 1.)

Choledochostomy was performed in the usual manner, and a No. 12 French catheter threaded proximally into the right hepatic duct. It was then possible to repair the rent in the duct wall over the catheter. The catheter and a cigarette wick, placed down to the site of the repair, were brought out through a lateral stab wound and the incision was closed.

Postoperatively the patient drained a moderate amount of bile through the catheter and drain for approximately ten days. Jaundice gradually sub-

sided, and the patient had a steadily improving course. He was discharged twenty-six days following operation. Follow-up examinations have shown that he has continued in good health with no further biliary tract difficulties.

Since 1946 we have seen only two other cases of traumatic rupture of the biliary tract. One was the case of a senile eighty-seven year old man who was admitted with a nine-hour history of abdominal pain and vomiting. No definite history of trauma was obtained. The abdomen showed diffuse generalized tenderness, spasm and rebound tenderness. Emergency laparotomy was performed, and at surgery about 1 L. of blood-stained bile was aspirated. No obvious source of leakage was noted; the gallbladder, cystic, common and hepatic ducts appeared grossly intact. The leakage, however, was not controlled until choledochostomy and cholecystostomy were performed.

Postoperative cholangiograms failed to visualize the left hepatic duct. This case raises the question of so-called spontaneous rupture of the bile ducts in the absence of biliary calculi. It was believed in retrospect that some possibly overlooked incident of trauma was the most likely precipitating factor in this case.

The other patient was a fifty-five year old man suffering from multiple injuries sustained in an automobile accident. He went into a state of shock approximately eleven hours after admission. Peritoneal tap at that time yielded dark bloody fluid which did not clot. After vigorous treatment for shock the patient's condition stabilized and he was operated upon. At surgery there was an obvious rupture of the gallbladder with a few small lacerations of the liver. The gallbladder and liver were drained and the wound closed. The patient died about an hour later due to intracranial hemorrhage which was disclosed at autopsy.

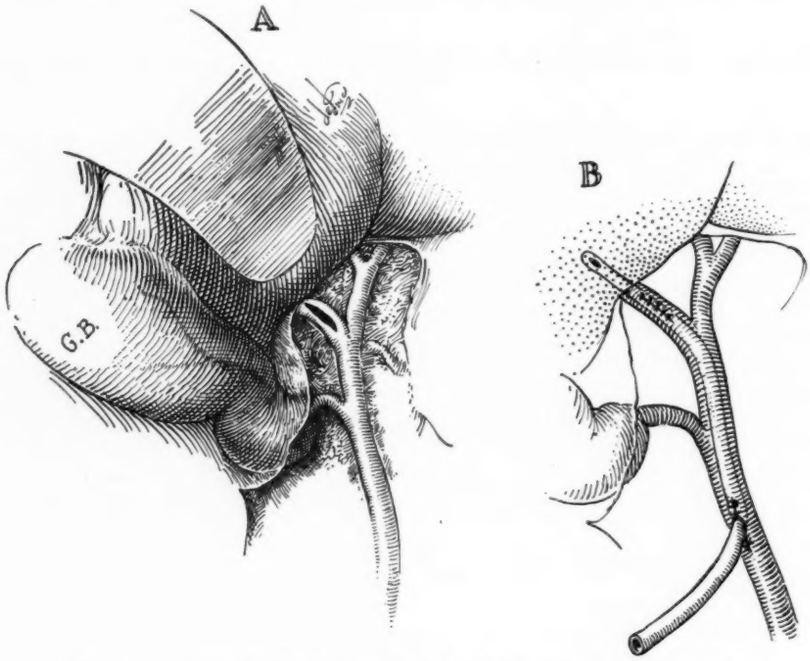

FIG. 1. A, operative findings; rent in right hepatic duct. B, repair.

COMMENTS

In most of the cases reported there was a history of severe crushing injury to the epigastrium and the right upper quadrant of the abdomen, frequently associated with fractures of the ribs of the right lower thorax. The patient was in profound shock initially and complained of pain in the right upper quadrant. Recovery from shock within a few hours was the rule. During the ensuing period of one to ten days there was gradually increasing jaundice and abdominal distention.

The preoperative diagnosis is often delayed by virtue of the confusing clinical picture. Associated retroperitoneal and thoracic injury produce signs and symptoms which tend to influence treatment along conservative lines. It is often not until clinical jaundice and increasing abdominal distention become evident that diagnostic peritoneal tap is performed, and the diagnosis of bile peritonitis becomes obvious. Therefore, we urge that immediate diagnostic peritoneal tap be carried out and

repeated in a few hours if necessary, in order that immediate definitive surgical treatment may be accomplished. It is hoped that some of the newer methods of intravenous excretory cholangiography will be of benefit in making the early diagnosis of these serious wounds.

Early operation as soon as the diagnosis is made or seriously suspected, with adequate drainage and decompression of the biliary tree, is the only satisfactory method of treatment. The exact operative procedure will, of course, vary according to the location and extent of damage to the biliary tract. When feasible, the rent should be carefully repaired, and the bile shunted from the area of repair by a suitable catheter or T-tube. When this is not possible, adequate drainage of the involved area of the bile duct rent will provide satisfactory decompression of the extrahepatic biliary tree, and allow healing to take place.

SUMMARY

1. A case of traumatic rupture of the right hepatic duct with bile peritonitis is presented.

2. Early diagnosis employing peritoneal tap and immediate surgical operation with establishment of adequate drainage are of utmost importance in the proper management of these cases.

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Hepatic Injuries

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Rupture of the liver following injury to the abdomen or chest presents a serious threat to life. Many of these injuries result in death from hemorrhage or bile peritonitis.

This report is based on eighteen patients we have treated for hepatic injuries in the past five years.

Table I
CAUSE OF LIVER INJURIES

Auto accident	12
Gunshot wound	3
Stabbing	1
Fall	1
Blow to abdomen	1
Total	18

Twelve patients had ruptured livers resulting from automobile accidents, three from gunshot wounds and one each from a fall, a stabbing and a blow to the abdomen. (Table I.)

Rib fractures were present in nine of the fourteen patients with closed injury to the liver. Four patients had rib fractures on the right, three on the left and two had bilateral rib fractures. Three patients also had rupture of the spleen and three had associated pelvic fractures. (Table II.)

Table II
ASSOCIATED INJURIES

Fractured ribs	9
Right	4
Left	3
Bilateral	2
Rupture of spleen	3
Pelvic fractures	3

The immediate signs and symptoms of ruptured liver were those of intraperitoneal hemorrhage. (Table III). Tenderness and rigidity were noted in sixteen instances. In eight patients this was most marked in the right upper quadrant, three in the left upper quadrant and three had generalized tenderness and rigidity while two had epigastric findings. Abdominal pain was present in fifteen instances and was also most frequently localized in the right upper quadrant. Bowel sounds were absent or decreased on admission in fourteen patients. Shock was present in fourteen patients.

Peritoneal aspiration, an additional diagnostic aid, was carried out in nine of the fourteen cases of closed injuries. In six instances blood was obtained. When penetrating injuries were evident, peritoneal taps were not considered necessary. An average of 2,000 cc. of whole blood was required in preparation for and during operation.

Table III
SIGNS AND SYMPTOMS OF RUPTURED LIVER

Tenderness and rigidity	16
Abdominal pain	15
Bowel sounds absent or decreased	14
Shock	14

The right lobe of the liver was involved in nine of the eighteen cases and the left in four. There were three cases involving both the right and left lobes. In two cases the location of the lesion was not known.

While non-operative management is still recommended by some, the unpredictable amount of bleeding and escape of bile from even small wounds make operation seem necessary in every case. Nine of the injuries in this study were treated with a combination of hemostatic gauze and suture. (Table IV.)

Table IV
OPERATIVE PROCEDURES

Hemostatic gauze and suture	9
Hemostatic gauze only	2
Celiotomy only	2
Cotton gauze packing	1
Drainage only	1
Total	15

Hemostatic gauze alone was used twice. In two instances of small lacerations no measures other than celiotomy and examination were performed. Cotton gauze packing was used in one injury in which the laceration was located on the dome of the liver. In one patient with a penetrating wound only drainage of the perihepatic spaces was performed. In four instances débridement of the liver tissue was necessary.

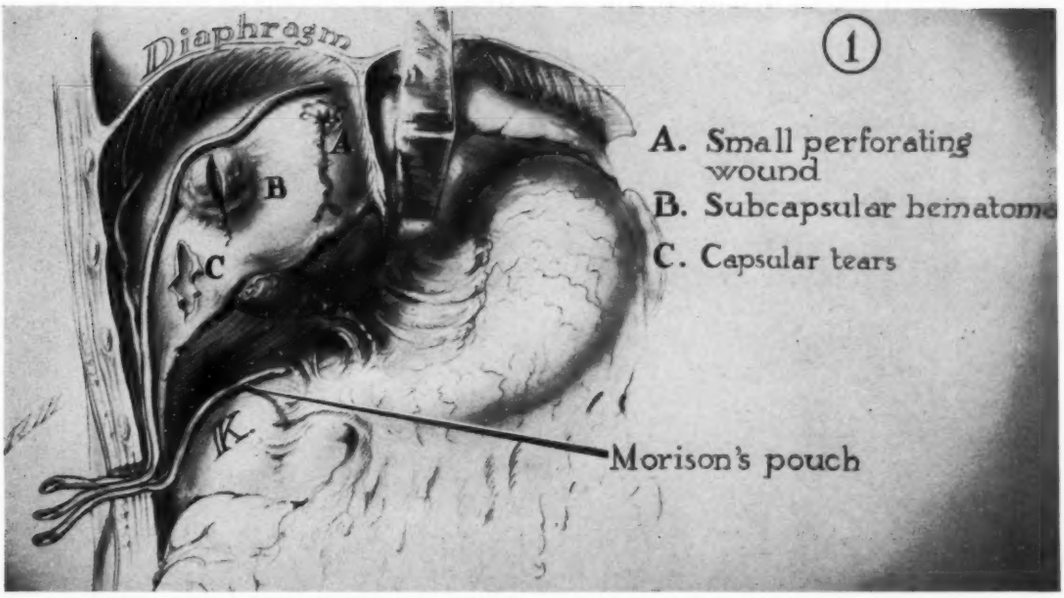

FIG. 1. Operative management of small perforating wounds, subcapsular hematoma or capsular tear.

This included ligation of bleeding points and bile ducts. All but one of the operative procedures was accomplished through the abdomen.

Of the fifteen operative cases, eight were drained. In five of the seven instances in which drainage was not carried out complications developed. (Table v.) These included subphrenic abscess, bile peritonitis and cul-de-sac abscess. One patient had hemobilia or hemorrhage into the biliary system from necrosis of liver substance. Only three complications developed in those patients who had perihepatic drainage. One case of fatal hemobilia occurred from lack of intrahepatic drainage. The other two complications were external biliary fistulas which closed spontaneously.

TABLE V
COMPLICATIONS OF OPERATIVE CASES

With drainage (8 cases):	
External biliary fistula	2
Hemobilia (liver parenchyma was not drained)	1
Total	3
Without drainage (7 cases):	
Subphrenic abscess	2
Bile peritonitis	1
Cul-de-sac abscess	1
Hemobilia	1
Total	5

Three of the eighteen patients were not operated upon either because of their precarious condition or missed diagnosis.

The average delay in operation was ten hours. This time was required to establish the diagnosis and prepare the patient for operation. For those who were operated upon the average length of treatment required two months.

Six of the eighteen patients died; two of the three not operated upon and four of the fifteen who were operated upon. (Table VI.)

TABLE VI
MORTALITY OF LIVER INJURIES

	Deaths
Non-operative treatment (3)	2
Operative treatment (15)	4
Total	6

Because of the high association of rib fractures with liver injuries, we regard all patients with lower rib fractures as potential liver injuries. We have found peritoneal aspiration to be helpful in patients suspected of having rupture of the liver. Negative taps were not considered conclusive and were repeated when indicated.

There are instances in this study in which liver injuries were closed without drainage of the perihepatic spaces. Closure of wounds without drainage was an unsound practice as is demonstrated by the larger number of complications in this group. Injuries to the liver result in varying degrees of liver necrosis and escape of blood and bile. It is impossible to assess accurately these factors at the time of operation. Because of the high mortality of bile

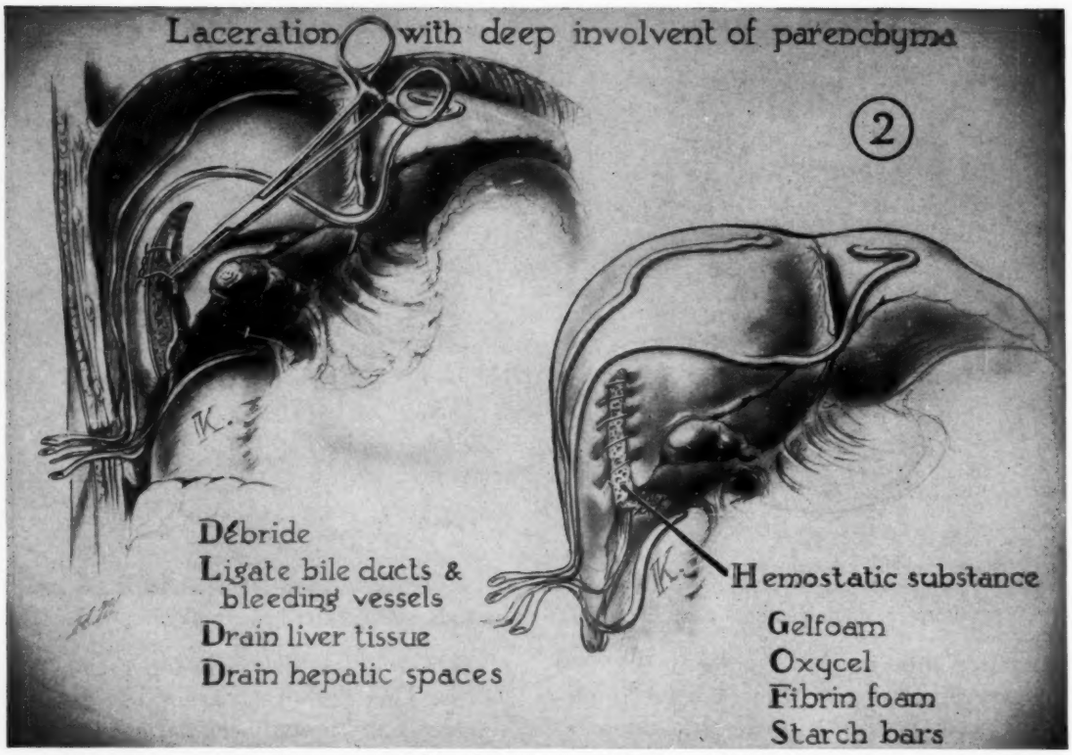

FIG. 2. Operative management of deep lacerations of the liver. Note the intrahepatic drain.

peritonitis, we believe that all liver injuries should be drained.

Operative measures vary with the type and location of the wound. With subcapsular hemorrhage or a capsular tear, clotting usually occurs spontaneously. The treatment in these instances consists of adequate drainage of the perihepatic spaces. Application of sutures in small superficial tears is optional. (Fig. 1.) For deeper lacerations, débridement when necessary and ligation of the biliary ducts and blood vessels is carried out and a drain placed in the liver parenchyma proper. (Fig. 2.) This is to prevent hemobilia. Hemostatic gauze is then placed in the laceration followed by application of absorbable sutures passing through the liver and the hemostatic gauze. The sutures are placed 2 to 3 cm. away from the torn edges and tied loosely, leaving the hemostatic gauze to control the slight oozing which inevitably occurs. Multiple drains are then placed in the perihepatic spaces. These drains are not removed until drainage is minimal. The intrahepatic drain is advanced with the others. Sparkman has reviewed the fourteen cases of traumatic hemobilia reported to date and noted a mortality of 50 per cent.[1] Because of the recent emphasis on this injury, we are reporting two cases.

CASE REPORTS

CASE 1. A nine year old boy was admitted one-half hour after being struck by a car. He was in shock and complained of pain in the right upper quadrant of the abdomen. Examination revealed tenderness and spasm in the right upper quadrant. After administration of blood, the blood pressure returned to normal. Subsequently abdominal distention with nausea and vomiting developed. Celiotomy revealed multiple lacerations of the right lobe of the liver. There was a necrotic area of the right lobe which was removed. The raw area and lacerations were treated with oxycel,® covered with omentum followed by closure without drainage.

Postoperatively fever developed with an intermittent ileus. On the eighth day jaundice developed. On the thirteenth day there was severe vomiting and hematemesis followed by tarry stools. There was no change in the blood pressure. On the seventeenth day celiotomy was repeated with aspiration of 4,000 cc. of dark bile-stained fluid and insertion of drains in the liver bed. Following this, his condition improved. On the sixtieth hospital day a right subphrenic abscess

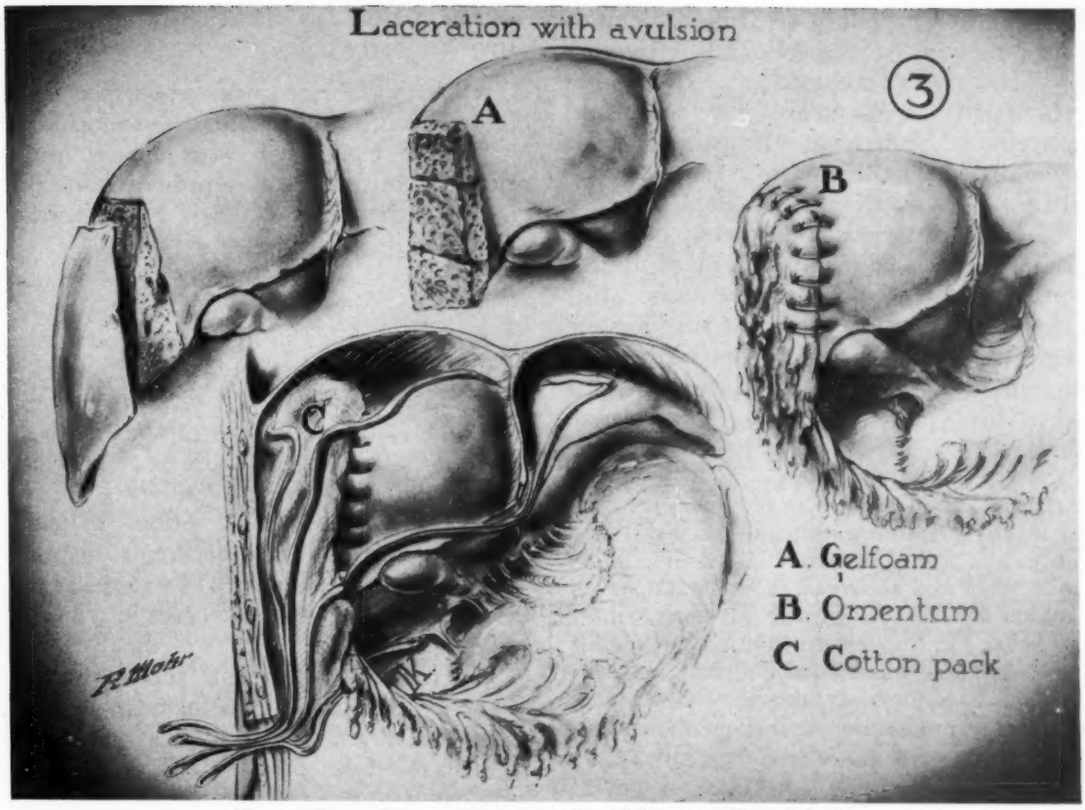

FIG. 3. Operative management of avulsion-type liver injuries.

was drained. Complete recovery followed this last procedure.

Comment. We suspect that hemobilia developed in this patient and was subsequently cured by its fortuitous rupture into the subphrenic space.

CASE II. A fifty-three year old white man was admitted shortly after striking a telephone pole while riding a motorcycle. He complained of pain in the right lower chest and epigastrium.

On examination a dull percussion note was present over the right chest inferiorly with absent breath sounds. Initially there were no abdominal findings. Shortly after admission shock developed. Chest x-rays showed fractures of ribs four to eight on the right. A peritoneal tap in the right upper quadrant produced fresh blood.

Celiotomy revealed a large amount of unclotted blood in the abdomen and a large deep laceration on the dome of the left lobe of the liver. There were also lacerations of the right lobe. The lacerations were packed with hemostatic gauze and the liver compressed against the diaphragm. One drain was placed in the subphrenic space and one in Morison's pouch. Postoperatively there was bloody drainage from the wound which subsided as his condition improved. However, he remained febrile. On the eleventh postoperative day epigastric pain with nausea, vomiting and shock developed. On the thirteenth day he was reoperated upon with a diagnosis of subphrenic abscess. Thirty cubic centimeters of pus and 200 cc. of serosanguinous material were aspirated from the right subphrenic space and multiple drains inserted about the liver.

Jaundice appeared and his condition deteriorated. On the eighteenth day operation was again carried out to control continuous bleeding from the wound. Packs were placed in the liver wounds and brought out on the abdomen. He continued to bleed and on the twenty-second day he passed a large tarry stool and shock developed.

Levin tube suction produced bloody material. On the twenty-fourth day shock again developed from which he never recovered.

The autopsy examination revealed a considerable amount of greenish black liquid in the large and small bowel, identified as blood and bile. On the superior surface of the right lobe of the liver there was a 4 cm. laceration which communicated directly with a large infarct measuring 6 by 6 by 7 cm. The necrotic center consisted of bloody debris. A branch of the portal vein was identified entering the necrotic cavity. The biliary system contained dark blood.

Comment. The patient appeared on his way to recovery until jaundice and uncontrollable hemorrhage occurred. We believe this patient might have been saved by intrahepatic drains.

With avulsion type injuries (Fig. 3) devitalized liver tissue is excised followed by ligation of the biliary ducts and blood vessels. Through and through mattress sutures may be an aid in controlling hemorrhage. Hemostatic gauze is then applied to the raw liver surface, followed by omentum which is sutured over the gauze. A cotton pack is then placed over the omentum and pressed firmly into place to provide pressure for additional hemostasis. Multiple drains are then placed about the liver for adequate drainage. The cotton gauze pack is withdrawn before removal of the drains. To illustrate this type of injury the following case is described.

CASE III. A nineteen year old man was admitted shortly after an automobile accident. The patient was in shock and complained of pain in the right chest and abdomen. There was marked rigidity and tenderness in the abdomen, most marked in the right upper quadrant. Bowel sounds were absent. There was evidence of fractured ribs on the right. A peritoneal tap produced fresh blood. After adequate preparation operation revealed an avulsion of the lateral half of the right lobe of the liver except for a small segment posteriorly. Hemorrhage was controlled by means of a rubber-shod clamp on the hepatoduodenal ligament. The devitalized lateral portion of the right lobe was then removed, and all bleeding points and bile ducts were ligated. Several mattress sutures were taken to provide additional hemostasis. Gelfoam® was then placed in sheets over the raw liver surface following which the omentum was brought up and sutured to the liver over the gelfoam. A large gauze pack was then placed against the omentum following which multiple drains were placed about the liver and brought out through a separate stab wound.

This patient has made an uneventful recovery from his injury.

All patients were given broad spectrum antibiotics to prevent the increased morbidity and mortality associated with infection.[2] Additionally, antibiotics may provide other benefits in the treatment of shock, as postulated by Fine and associates.[3]

CONCLUSIONS

1. Rupture of the liver was a serious injury resulting most frequently from automobile accidents in 18 patients we have treated.

2. Associated fractures of the ribs occurred in more than half of those patients suffering indirect injuries to the liver.

3. The signs and symptoms of ruptured liver were those of intraperitoneal hemorrhage. Peritoneal aspiration helped establish the diagnosis in two-thirds of the cases in which it was used.

4. The most important factors in the treatment of liver injuries are hemostasis, débridement and drainage. In deep lacerations drainage of the liver parenchyma is necessary to prevent hemobilia. In all injuries to the liver the perihepatic spaces should be drained.

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Treatment of Injuries of the Large Bowel in Civilian Practice

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PERFORATING injuries of the large intestine are among the most lethal of all abdominal injuries and present problems distinct from similar injuries to the other viscera. These differences chiefly concern the virulent nature of the fecal stream, the fixed position of the large intestine throughout much of its course, the wide avenues for retroperitoneal sepsis that may be opened following injuries to it, and the broad range of intraluminal pressures to which it may be subjected, placing undue strain on suture lines.

Our present understanding of the management of these serious injuries has come largely from experience with battle casualities from the two World Wars. This paper reviews a portion of this experience, particularly that from World War II, and discusses twenty-three cases of penetrating injuries of the large intestine encountered during the past twelve years on the Stanford Surgical Service at the San Francisco City and County Hospital. Although the number of cases presented is small compared to the large series reported from World War II, it is believed that certain factors distinguish these civilian cases from the military ones. These factors, chiefly, are a shorter time interval between injury and definitive care, the immediate availability of blood, the use of the broad spectrum antibiotics, the relative infrequency of severe associated injuries, and the continuity of care offered and warrant, in some cases, a departure from the proved lessons of military surgery and offer a considerably better prognosis.

Prognosis is dependent largely on the presence or absence of fecal contamination, associated injuries and shock. Jarvis[4] and others state that gross fecal contamination is the single most lethal factor. Taylor and Thompson[8] contrast a mortality rate of 65 per cent when fecal contamination was present against one of 25 per cent when it was absent. Colcock[1] has stated that patients dying after the first twenty-four hours do so from sepsis. He cites the possible causes of sepsis, other than initial contamination, as: (1) failure to close an unrecognized perforation, (2) secondary perforation with peritonitis from a traumatized area of bowel, (3) failure to remove a retroperitoneal foreign body, and (4) the development of intraperitoneal, lumbar and subphrenic abscesses from retraction of an exteriorized segment of bowel. Associated injuries, of course, adversely affect prognosis. Colcock,[1] reviewing the experience from World War II, states that approximately 40 per cent of large bowel injuries had wounds of other intra-abdominal organs and in 30 per cent the small bowel was the organ involved. The presence of shock before, during or following surgery indicates a less favorable prognosis. Taylor and Thompson[8] state that the continuation of shock, once it has been corrected, probably indicates continuing disguised hemorrhage, disturbance of the cardiorespiratory mechanism from thoracic injury, massive fecal contamination or early, fulminating anaerobic infection with gas-forming organisms. They and others stress that the failure of the patient to respond to adequate shock treatment, or to relapse after it has been corrected, should not constitute cause for delay in surgical intervention, but on the contrary should point the way to immediate exploration.

It is readily apparent that the management of perforating wounds of the colon and rectum has been and is a matter of some controversy. The trend has gone from the wide use of primary suture during World War I to the broad application of exteriorization in World War II to the present time, when emphasis, at least in civilian cases, is again being placed on primary

suture in selected cases largely because of the advent of the broad spectrum antibiotics. Essentially four methods of operative management may be employed: (1) primary suture, (2) exteriorization, (3) proximal diversion of the fecal stream and (4) resection.

Primary suture, though non-shocking, involving a considerably shortened convalescence without the necessity of secondary procedures, and performed with ease and speed, has as its major potential disadvantage the danger of breakdown of the suture line with resultant fecal contamination. However, it is of interest, as noted by Taylor and Thompson,[8] that almost no cases were recorded in World War II in which the sutured wound in the colon broke down, and that the mortality rate was the lowest of any method—22 per cent as averaged from several military series. In general, however, primary suture was reserved for wounds of lesser magnitude. Woodhall and Oschner[12] in 1951 and Tucker and Fey[9] in 1954 have shown that primary suture in selected cases is a sound procedure.

Most surgeons with experience in World War II have believed that exteriorization is the method of choice in combat casualties and was the single most important technical factor contributing to the improvement in mortality rate from 60 per cent during World War I to 35 per cent in World War II.[8] Exteriorization eliminates continued fecal contamination, leaves no suture line within the abdomen and allows for decompression of the bowel through the exteriorized segment. Its chief disadvantage is that the mobilization required to permit exteriorization of the fixed portions of the colon can be a shocking procedure in the poor risk patient. There are the additional hazards of severe cellulitis in the broad retroperitoneal planes opened following mobilization of the fixed portions of the colon and of retraction of the exteriorized segment with resultant fecal contamination of the abdominal wall or cavity. Colcock[1] has categorically stated that "any perforating wound of the colon should be exteriorized on the surface of the abdomen or, if this is not feasible, the wound should be closed and a proximal colostomy performed." Woodhall and Ochsner[12] advanced the thesis that the writings of the American surgeons with broad military experience influenced to a great degree the management in civilian cases with overemphasis on the use of exteriorization. They made a plea for the more frequent use of primary suture in selected cases in civilian practice.

Proximal diversion of the fecal stream is accomplished by ileostomy, cecostomy or colostomy. These stomas, by minimizing or abolishing the fecal stream distally and reducing intraluminal pressure, protect the wounds and suture lines. Ileostomy is unsatisfactory because of the possible severe electrolyte and fluid loss. Cecostomy, while decompressing the bowel, diverts the fecal stream only partially. Loop colostomy, though superior to cecostomy in this respect, still does not defunctionalize the bowel completely. This may be accomplished by dividing the bowel and performing double-barrelled spur colostomy or actually separating the bowel ends several centimeters apart. Diversion of the fecal stream generally is used in conjunction with suture of the wound or with local drainage.

All authorities agree that resection is best avoided because of its prohibitive mortality. It finds application chiefly in extensive injuries of the right colon. The reasons for this are two: first, diversion of the fecal stream, mandatory in extensive wounds, can be established only by ileostomy, which is objectionable because of the danger of severe fluid and electrolyte loss and the digestive action of ileal drainage on the abdominal wall. Thus, recourse is had to resection and anastomosis. Second, as pointed out by Ogilvie,[5] "anastomosis between small and large bowel has few of the risks of colon-to-colon anastomosis since the material passing the suture line is fluid, not very infective and flows at an even rate and at low pressure." Taylor and Thompson[8] favor ileotransverse colostomy following resection and recommend that the proximal end of the transverse colon be brought out through a separate stab wound as a safety valve. Colcock[1] is opposed to anastomosis following resection of the right colon because it adds considerably to the operating time and leaves a potentially dangerous suture line within the abdomen. He favors double-barreled spur ileotransverse colostomy and states he has begun destruction of the spur as early as the seventh day with subsequent closure of the stoma by an extraperitoneal procedure.

It is obvious that all these procedures and combinations thereof will have a distinct place in the management of these wounds. The

severity and nature of the wound usually will dictate which surgical principle is to be used rather than the preference of the surgeon. An extensive, jagged wound of the colon cannot be sutured safely, but ordinarily must be exteriorized; whereas a small, clean laceration can be sutured primarily with confidence as to the ultimate outcome. Thus the problem resolves itself into one of surgical judgment and case individualization, rather than strict adherence to a particular dictum. The appeal that primary suture has in civilian practice is understandable since considerable priority must be placed on minimizing hospital expense and time lost from work.

It is in wounds of the rectum, however, that more rigid operative management is justified. The intraperitoneal rectum cannot be exteriorized and must be handled by suture combined with proximal colostomy. Sometimes it may not be possible to suture the perforation and the suggestion of Wallace[10] may be used. This consists of converting the wound to an extraperitoneal one by elevating the rectovesical pouch. The management of this type of wound will be discussed. Simple loop sigmoid colostomy is adequate for all but the most extensive wounds in this area, in which event complete diversion of the fecal stream must be established.

As cited by Taylor and Thompson,[8] the mortality rate in wounds of the extraperitoneal rectum is the lowest for any portion of the large intestine, approximately 6 per cent in World War II in contrast to World War I when virtually all were fatal. The major factor causing death has been fulminating pelvic cellulitis. Treatment embodies two principles: (1) proximal colostomy and (2) drainage of the retrorectal space. Colostomy should provide for complete diversion of the fecal stream. Taylor and Thompson[8] favor the left inguinal region as the site for the sigmoid colostomy. However, if further surgery is contemplated in the future in the left lower quadrant, transverse colostomy should be performed. Drainage of the retrorectal area is accomplished by an incision lateral to or below the tip of the coccyx. Coccygectomy is not necessary for adequate drainage and when performed, has been complicated by osteomyelitis of the sacrum. Whether or not the rectal wounds should be sutured apparently is not of importance if the two cardinal principles of adequate local drainage and fecal stream diversion are performed. If the perforation can be closed without too much difficulty, it should be sutured.

Prior to Woodhall and Oschner's report in 1951[12] civilian mortality rates consistently exceeded those of World War II. They reported fifty-five cases with a mortality rate of 20 per cent and advised the use of primary suture in selected instances. In 1954 Tucker and Fey[9] also recommended simple suture in certain cases, citing reduced mortality and morbidity figures to back up their advice. (Table I.)

TABLE I
MORTALITY RATES IN LARGE BOWEL INJURIES

Authors	Year	No. of Cases	Mortality (%)
Civilian:			
Rippy[7]	1941	32	62.5
Elkin and Ward[2]	1943	17	53
Wilkinson, Hill and Wright[11]	1946	37	76
Woodhall and Ochsner[12]	1951	55	20
Tucker and Fey[9]	1953	42	14.3
Present series	1954	23	0
Military:			
Ogilvie[5]	1944	160	53
Taylor and Thompson[8]	1948	70	27.1
Porritt[6]	1946	440	45

Our experience substantiates the tendency in recent years to treat large bowel injuries encountered in civilian practice more radically than those seen in military practice. Between 1942 and 1954, twenty-three consecutive cases of injury of the colon or rectum were cared for on the Stanford University Service at the San Francisco County Hospital without a fatality.

We believe that a more radical procedure is possible in civilian practice since civilian injuries differ from combat wounds in the following ways: (1) the wounds, as a rule, are less extensive, (2) the time lag between injury and surgery is shorter, (3) the treatment of shock can be started sooner and carried on more vigorously, (4) the patient is under continuous care by the same physician.

The availability of wide spectrum antibiotics assures the success of more radical treatment.

Site of Injury. The sites of injury of the large bowel are shown in Table II. The most common site was the transverse colon (ten

cases), followed by the sigmoid (five cases) and the rectum (three cases), the splenic flexure (two cases) and the cecum, descending colon and rectosigmoid (each one case).

Associated Injuries. In seventeen of the twenty-three cases associated injuries of other abdominal organs occurred. The small bowel was injured most frequently, being involved eleven times. (Table III.)

TABLE II
SITE OF INJURY

Cecum	1
Ascending colon	0
Hepatic flexure	0
Transverse colon	10
Splenic flexure	2
Descending colon	1
Sigmoid	5
Rectosigmoid	1
Extraperitoneal rectum	3
	23

Mechanism of Injury. Gunshot wounds (thirteen cases) were the most common mode of injury, followed by stab wounds (eight cases). Two wounds of the rectum were caused by assault. (Table IV.) Although by its nature a gunshot wound is apt to be more traumatic than a stab wound, we found no appreciable difference in the complications or period of convalescence between the two.

TABLE III
ASSOCIATED INJURIES OF OTHER ORGANS

Small bowel	11
Stomach	1
Spleen	1
Kidney	2
Ureter	1
Urinary bladder	1

TABLE IV
MECHANISM OF INJURY

Gunshot wounds	13
Stab wounds	8
Others	2

Age and Sex of Patients. The ages of the patients varied from seventeen to fifty-four years, with an average of thirty; all but four patients were men.

Interval between Injury and Surgery. The great majority of patients (sixteen cases) were taken to surgery within five hours of injury. All but four were operated upon within ten hours. These four were treated surgically sixteen, forty-three, forty-eight and fifty hours after injury. (Table V.)

Preoperative Preparation, Surgical Treatment and Complications. Shock, which was present in six patients on entry, was corrected prior to surgery. Blood was not given routinely, but only when indicated by evident hemorrhage or shock. Seventeen patients were given blood either before or during surgery. We believe, as do others, that when shock persists in the face of adequate treatment, it may indicate intraperitoneal hemorrhage or massive fecal contamination and is an indication for surgery.

TABLE V
TIME INTERVAL BETWEEN INJURY AND SURGERY

Time	No. of Patients
1–5 hours	16
5–15 hours	3
Over 15 hours	4

Preoperative x-rays were taken in fifteen cases. In stab wounds of the abdomen early exploratory laparotomy is indicated and little is gained by x-ray examination. The same may be said for gunshot wounds when a wound of exit is present. When only the wound of entry is visible, localization of the missile by x-ray examination may be helpful in plotting its course. When bladder wounds are suspected and laparotomy is indicated, cystograms are unnecessary since the bladder can be explored through the surgical incision.

Eight of our patients were treated by suture alone; these all healed uneventfully. Three were treated by suture with proximal cecostomy, four by suture with proximal colostomy, four by exteriorization, one by colostomy alone, one by resection and proximal cecostomy, one by colostomy and drainage of the retrorectal and retroperitoneal spaces, and one (an injury of the rectum just above the mucocutaneous line) by débridement of the wound, but no surgery on the bowel. (Table VI.)

In three instances there was gross fecal contamination of the peritoneal cavity. Two of these healed uneventfully; in the third a pelvic abscess developed and was drained. Retention sutures were used in eleven of the twenty-two cases operated upon. One wound dehiscence occurred in a patient without retaining sutures.

Postoperative wound infections developed in six patients, an incidence of 25 per cent. In three cases evidence of pelvic inflammation occurred. In two of these the mass subsided spontaneously and in the third case, which was

mentioned previously, it was necessary to drain the abscess.

One patient suffered with a pulmonary embolus eight days after surgery, from which he recovered. One other patient had a prolonged convalescence because of atelectasis, a poorly functioning colostomy and a prolonged paralytic ileus. He also recovered. (Table VII.)

TABLE VI
METHOD OF TREATMENT

Primary suture	8
Suture and proximal cecostomy	3
Suture and proximal colostomy	4
Exteriorization	4
Resection with proximal cecostomy	1
Colostomy and drainage of retrorectal space (rectal injury)	1
Local débridement (rectal injury)	1
Colostomy alone (rectal injury)	1

In only one instance was the type of complication dependent upon the method of local treatment of the bowel. In this instance the patient sustained severe lacerations of the rectum during an assault. Although she was placed on antibiotics, the rectal injuries were not treated surgically until twenty-four hours after entry. By this time infection had ascended along the perirectal space into the retroperitoneal area and cellulitis of the retroperitoneal space was visible at exploration. In spite of the establishment of colostomy and drainage of the retroperitoneal and retrorectal spaces, a retroperitoneal abscess developed which later had to be drained. The proper treatment in this case would have been immediate surgery with construction of colostomy and drainage of the retrorectal space.

TABLE VII
COMPLICATIONS

Wound infection	6
Pelvic inflammatory mass	3
Abscess, retroperitoneal	1
Pulmonary embolus	1
Dehiscence	1
Poorly functioning colostomy, atelectasis	1

During the preparation of the patient for surgery a thorough search for the wound of exit or a foreign body under the skin should be undertaken in order to avoid needless x-ray examinations and harmful movement of the patient. An inlying catheter should be inserted if there is the slightest suspicion of a bladder injury. Whenever a rectal injury is suspected, both digital and proctoscopic examination should be undertaken.

COMMENTS

Eight of our twenty-three cases were treated by suture alone. These all healed uneventfully. In light of this experience a review of the treatment employed in each of our early cases made it evident that simple closure might well have been employed in seven additional patients without undue risk.

Simple suture can be performed easily and quickly. Its success is made possible by the use of wide spectrum antibiotics. When used in properly selected cases, it cuts operative time, reduces the number and extent of operations and decreases the length of hospital stay for the patient.

SUMMARY

1. Most small, grossly clean wounds of the large bowel may be sutured and returned to the abdomen without the establishment of proximal colostomy.

2. Large, grossly contaminated wounds are best treated by exteriorization when feasible.

3. Resection of the unprepared large bowel should be avoided whenever possible.

4. Retroperitoneal contaminated areas should be drained through the flank; however, drainage of the peritoneal cavity *per se* should be avoided.

5. All wounds of the extraperitoneal rectum should be drained posteriorly by opening the retrorectal space in the hollow of the sacrum through the rectococcygeal ligament.

6. Exploratory wounds of the abdomen in the face of gross fecal contamination should be closed with retention sutures and the skin left open for secondary closure.

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Traumatic Rupture of the Normal Spleen

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THE present paper is an attempt to define the syndrome of pure splenic rupture by the statistical analysis of sixteen such cases seen in the last five years. These cases have not been reported heretofore and are added to the literature.

There has been a considerable amount written about rupture of the spleen,[2–4,7,8] but most of the papers have been complicated by the addition of cases of rupture of the pathologic spleen or cases in which violent injury has occurred, and the splenic rupture was only a concomitant of other severe abdominal injury.

It is not meant to minimize the importance of thinking of, and recognizing, a ruptured spleen when associated with other injuries, for such neglect leads to greatly increased mortality. However, the early recognition and treatment of simple rupture of the spleen converts a potentially dangerous condition into one with a gratifyingly low morbidity and mortality.

Type of Injury. The history of injury in this type case may not be impressive. The force of the trauma may seem small and in cases of delayed rupture there may be no memory of the occasion leading to the injury. In all of the cases reported herein the injury was of such nature. Table I summarizes the type of trauma producing the rupture.

The automobile has been indicted by other authors in this type of injury.[1,5,7,8] Such was not the case in our series. Only three patients were involved in car accidents, the remainder being injured by falls or blows to the left side. The age distribution of our series inclines markedly toward the younger years. (Table I.) Over half of all the cases were children, the youngest being six and the oldest thirteen. All but two of the remainder were young adults. The oldest patient was fifty-seven years old.

Six of our cases, or 37 per cent, were of delayed rupture. The time interval varied from three days to three and a half months (Table II.)

It is not possible to tell at the time of operation whether the original injury was a subcapsular hematoma with delayed rupture or whether a small tear was present at the onset from which bleeding was minimal until later in the course of the ailment. It is presumed that the onset of the present illness indicates the time of rupture.

TABLE I

Case No.	Age (yr.), Sex and Color	Method of Injury
1	6, M, W	Struck by car, left side
2	6, M, W	Hit left side jumping in bed
3	55, M, W	Pipe fell on left side
4	28, M, W	Auto accident
5	11, M, W	Fall on abdomen
6	30, F, W	Hit by husband, left side
7	24, F, N	Hit by husband, left flank
8	26, M, W	Spontaneous?; pleurisy left chest 3½ months
9	23, M, W	Fall from horse; struck left side against pole
10	57, M, W	Fall, striking left side on thermos flask
11	10, M, W	Struck by car, left side
12	7, F, W	Struck left side on handle bar tricycle
13	11, F, W	Struck on left side by playmate
14	13, M, W	Fall on abdomen playing football
15	10, M, W	Fall on abdomen, 6 feet
16	10, M, W	Struck on left side by ball bat

An examination of the findings at operation (Table III) will show no correlation between the type of splenic trauma and whether or not the case was one of delayed rupture.

As has been stated previously, the trauma was not of violent nature, and there was no loss of consciousness in any of the cases at the time of injury. Two of the patients (Cases 10 and 13) lost consciousness briefly at a later date by fainting.

Table II shows an inordinately long interval

between the onset of the present illness and admission to the hospital and between admission to the hospital and operation. It was partly this factor which caused the author to review these cases to see if some new light could be thrown on the diagnosis of the condition so that more prompt definitive therapy could be carried out. This long interval points up the fact that diagnosis has not been easy even when the possibility of ruptured spleen is kept in mind. The high white blood cell count may erroneously point to an inflammatory condition, and the patient's apparent well-being often leads to a false sense of security. (Table IV.)

TABLE II

Case No.	Time Elapsing from Injury to Onset of Present Illness	Time Elapsing from Onset of Present Illness to Admission (hr.)	Time Elapsing from Admission to Operation (hr.)
1	Immediate	¾	4
2	4 days	4	4
3	Immediate	20	9
4	7 days	2	¾
5	2 hr.	12	12
6	3 days	2	2
7	7 days	10	1½
8	3½ months	12	1
9	Immediate	¾	8
10	Immediate	6½	5
11	Immediate	1	2½
12	Immediate	4	1½
13	2 weeks	12	24
14	Immediate	18	6
15	Immediate	4	6
16	Immediate	3	24

Diagnosis. The diagnosis of this condition is made, like other surgical conditions, from the aggregate of symptoms, signs and laboratory procedures.

The most constant symptom elicited in these sixteen cases was abdominal pain. (Table V.) This was complained of by all but two patients (Cases 12 and 16). The pain was generalized, but careful questioning revealed it to be more marked on the left in eleven of the fourteen patients who complained of pain. One patient (Case 8) localized the pain in the right lower quadrant. Four localized it to the left lower quadrant. Nine patients complained of pain in the left chest spontaneously, and it was found that if the patient was asked to inspire deeply, chest pain was a constant finding. All but two complained of it with this maneuver. Even the patient with right lower quadrant pain had chest pain on deep inspiration.

TABLE III*

Case No.	Appearance of Spleen at Operation
1	Deep laceration from margin to hilum (4 cm. by 1 cm. by 1 cm.)
2(D)†	Transverse laceration near center
3	Laceration 1 cm. deep extending over entire surface
4(D)	Spleen broken into five fragments
5	Spleen bisected near pedicle
6(D)	Contused laceration on anterior surface near inferior margin
7(D)	Transverse laceration at one pole
8(D)	Laceration near hilum; large hematoma in ligaments of pedicle
9	Cruciate laceration of convex surface
10	Extensive laceration; underlying hematoma
11	Multiple laceration; ligaments of spleen infiltrated
12	Bisected in mid-portion; large gastrosplenic hematoma
13(D)	Longitudinal laceration; underlying hematoma
14	Complete laceration (bisected) across lower pole
15	One-half inch deep laceration 2 inches long at lower pole
16	Bisection of spleen at middle

* All had large quantities of free blood and clots in the peritoneal cavity

† D = delayed rupture

Pain referred to the left shoulder has been described as a rather inconstant symptom,[5,7,8] but we found it otherwise. It was present spontaneously in ten of the sixteen patients and if pressure was put on the left hypochondrium, all but two complained of left shoulder pain. Three of the patients also had pain in the right shoulder. This observation might tend to lend support to the idea that visceral afferent fibers are carried from the spleen via the phrenic nerve.[6]

A feeling of weakness was also a prominent symptom. This type of complaint is hard to evaluate.

A history of nausea and vomiting was obtained in only six of the sixteen. Of these, two reported coffee ground material.

The physical signs, taken separately, were

TABLE IV

Case No.	Pulse (per min.)	Temperature (°F.)	Respiration (per min.)	Blood Pressure	Red Blood Count	Hemoglobin		White Blood Count	Neutrophils (%)
						Gm.	(%)		
1	132	99	32	140/80	5,106,000	11.1	75	40,000	58
2	140	99.8	32	94/78	1,950,000	6.5	41	19,750	78
3	90	98	28	140/90	4,100,000	12.4	80	10,800	79
4	130	100	22	70/30 S*	3,950,000	12.0	77	15,800	83
5	108	98.2	28	120/60	4,220,000	12.4	80	12,100	66
6	124	100	38	55/40 S	3,260,000	10.0	64	16,250	95
7	104	99	28	80/50 S	3,650,000	10.75	69	14,600	87
8	96	99.8	20	130/80	3,750,000	12.4	80	10,100	68
9	104	99.4	26	124/78	4,700,000	13.0	89	17,200	95
10	64	97.8	18	90/60 S	4,100,000	12.0	82	14,250	90
11	120	103	32	96/56	3,800,000	11.0	75	15,200	89
12	120	100.2	26	98/60	3,230,000	9.5	65	17,450	86
13	128	102	36	116/64	3,030,000	8.5	58	7,850	98
14	148	99.8	36	100/70	3,360,000	9.0	62	23,850	78
15	140	100.6	28	104/60	4,760,000	12.5	86	14,200	78
16	110	100.2	24	108/60	3,000,000	7.5	51	15,800	66

* S = Shock clinically.

TABLE V

SYMPTOMS

Case No.	Abdominal Pain	Localization of Abdominal Pain	Shoulder Pain	Nausea and Vomiting	Left Chest Pain
1	Generalized	Left lower quadrant	None	None	With deep inspiration
2	Generalized	Epigastrium	Left with pressure in left upper quadrant	None	With deep inspiration
3	Epigastrium and left lower quadrant	Epigastrium and left lower quadrant	Left; marked	+	+
4	Generalized	None	Both; marked on left	None	+
5	Generalized	Left lower quadrant	Left with pressure in left upper quadrant	+ coffee ground	With deep inspiration
6	Generalized; severe	Left side	Left	+	+
7	Generalized	Left lower quadrant	Both; more on right	None	+
8	Generalized	Right lower quadrant	None	None	With deep inspiration
9	Left abdomen	Left abdomen	Left	None	+
10	Left abdomen	Left abdomen	Left; marked	None	+
11	Left abdomen	Left abdomen	Left	None	+
12	None		Left on pressure in left upper quadrant	None	None
13	Generalized	Left side	Both; more on left	+	+
14	Generalized	Left side	Left	+ coffee ground	With deep inspiration
15	Generalized	Left flank	Left	+	+
16	None	.....	Left with pressure in left upper quadrant	None	None

not impressive, but in the aggregate were of considerable significance. (Table VI.)

Perhaps the most constant sign was that of pallor, particularly circumoral pallor, with an anxious facies in a listless patient. This finding was present even when the patient otherwise appeared well. We were much impressed by this sign and look for it always. This sign has also been stressed by other observers.[4]

Bowel sounds were normal to hypoactive and not a reliable finding.

No abdominal mass was palpated in any of this series, and an attempt to elicit shifting dullness was disappointing.

Another constant abdominal finding, when looked for, was a decrease of the costal flare, more marked on the left. This is an important sign because it indicates restriction of diaphragmatic motion either by reason of irritative spasm or increased pressure against it.

TABLE VI
PHYSICAL EXAMINATION

Case No.	Pallor	Muscle Rigidity	Abdominal Tenderness	Palpable Masses	Rectal Tenderness	Diminished Left Costal Flare
1	+	L.L.Q.* +++	L.L.Q.	None	+++	Present
2	+	Upper abdomen +++	Epigastrium and L.U.Q.	None	None	Present
3	+	L.U.Q.† +++	L.U.Q. and epigastrium	None	+	Present
4	+	Generalized ++++	Generalized L.U.Q.	None	+++	Present
5	+	Generalized ++++; more marked L.U.Q.	Generalized L.U.Q.	None	None	Present
6	+	L.L.Q. ++	L.L.Q.	None	+++	Present
7	+	Generalized ++	L.L.Q.	None	++	Present
8	+	Epigastrium and R.L.Q. +++	R.L.Q.	None	++++	Present
9	+	Guarding + L.U.Q.	L.U.Q.	None	++	Present
10	+	Guarding + L.U.Q.	L.U.Q.	None	+	Present
11	+	Generalized on left +++	Generalized and L.U.Q.	None	+	Present
12	+	Guarding L.U.Q.	L.U.Q.	None	++	Present
13	+	Generalized +++	Generalized and L.U.Q.	None	++	Present
14	+	Generalized +++	Epigastrium	None	+	Present
15	+	None	L.U.Q.	None	+	Present
16	+	Slight guarding + L.U.Q.	L.U.Q.	None	+	Present

* L.L.Q. = left lower quadrant
† L.U.Q. = left upper quadrant

The abdominal examination showed some constant features. There was always some degree of increased muscle tone which varied from guarding to frank rigidity. In nine of the sixteen cases there was definite rigidity, and this was more marked in the left abdomen, usually the left upper quadrant. In two the rigidity was more marked in the left lower quadrant and in one in the epigastrium and right lower quadrant.

Abdominal tenderness of some degree was also found in all cases. The tenderness was generalized as a rule but was more marked in the left upper quadrant in twelve cases, in the left lower quadrant in three cases and in the right lower quadrant in one. There was rebound tenderness in a few cases, but this finding was not constant.

All but two of our patients had rectal tenderness, and it is believed that this finding has not had sufficient attention in the past. The tenderness, however, was not localized and is considered an adjunctive sign.

In the case of a ruptured solid viscus, such as the spleen, with a large quantity of blood found in the peritoneal cavity, one would expect a considerable degree of shock. Such was not the case in our series. Four of our patients did exhibit shock, two frankly and two questionably (Cases 4, 6, 7 and 10). It was not severe. In the remainder the blood pressure was normal to slightly elevated. (Table IV.)

There were two factors which pointed to blood loss; the red cell count and the pulse

rate. The red cell count was moderately lowered, although not to the degree one would expect from such bleeding. The average count for all cases was 3.7 million, probably because hemodilution had not occurred. The lowest count was 1,950,000, the highest, 5,106,000; both in children. (Table IV.)

In the patients who underwent a period of observation there was a further slow fall in the red cell count.

The pulse rate was consistently elevated and is an important sign. In the patients who underwent a period of observation the pulse rate gradually increased. The average in the child group was 128/min. and in the adult group 104/min.

The respirations were more rapid also, averaging 30/min. in the child group and 26/min. in the adult group.

The temperature averaged 99.8°F. The highest temperature was 102°F. and the lowest 97.8°F.

The white blood cell count was elevated in all but one case. The average in the child group was 17,360 and in the adult group, 14,143. As can be easily imagined, this finding together with abdominal rigidity and tenderness could well lead the unwary to a diagnosis of an inflammatory lesion. The differential count averaged a percentage of neutrophils, including young forms, of 87 per cent.

Taken by themselves the roentgen findings have not been pathognomonic, by any means, in this series. Yet in two patients (Cases 12 and 16) they were decisive in the diagnosis. Table VII is a summary of the findings in our cases.

In three cases no x-ray films were obtained. In four patients there was slight gaseous distention of the intestine with no other findings. Four cases showed increased density alone in the splenic area, and in five cases there was evidence of the serrated greater curvature of the gas-filled stomach being displaced medially. In three of these latter cases the displaced stomach was associated with increased splenic density.

A summary of the diagnostic findings as might be encountered in the typical case is as follows: The patient is listless and pale but aside from this may appear quite well. He complains of moderate generalized abdominal pain, more marked on the left with reference to the left shoulder. This latter can be produced or aggravated by deep pressure in the left hypochondrium. There is left chest pain on deep inspiration, and inspiration is restricted as evidenced by diminished costal flare.

His history will reveal that he has had trauma to the left side of the trunk. This trauma need not be of violent nature and may have occurred in the more remote past.

TABLE VII

Case No.	X-ray Findings
1	Increased density splenic area
2	Not done
3	Small bowel distention; displaced greater curvature of gas-filled stomach irregular and crenulated
4	Not done
5	Increased density of splenic shadow; slight gaseous distention small and large bowel
6	Not remarkable; small bowel distention
7	Not done
8	Moderate distention of large bowel
9	Increase in density in splenic area
10	Splenic shadow enlarged
11	Gaseous distention stomach and colon
12	Soft tissue mass splenic area; gaseous, distended stomach displaced medially
13	Gaseous, distended stomach; irregular greater curvature displaced medially
14	Splenic shadow enlarged with stomach displaced medially; greater curvature irregular
15	X-ray showed no pathologic disorder; some gaseous distention of bowel
16	Greater curvature of stomach serrated and displaced medially

There is tenderness to rectal palpation and generalized abdominal tenderness, more marked on the left.

The temperature is but slightly elevated; the respiratory rate, and particularly the pulse, more so. Shock is ordinarily not present and indeed the blood pressure may be above normal.

Laboratory studies show a moderately depressed red blood cell count, usually of a range of 3.2 to 3.8 million, with the hemoglobin value in proportion. The white blood cell count is considerably elevated with percentage increase of the neutrophils.

A flat plate of the abdomen will show some increase in density in the splenic region and may show the serrated greater curvature of the gas-distended stomach displaced medially. Continuous observation of the patient with a

suspected ruptured spleen is stressed. If the previously mentioned findings are not present at the first examination, they will nevertheless appear if observation is continued.

Treatment. The treatment of this condition is immediate splenectomy. The procedure is an easy one, is not attended with much risk, and to our knowledge no harm has resulted from an absent spleen, even in children. Other observers have commented on this.[7] We like to transfuse these patients preoperatively, but if blood is not available we do not delay operation because if transfusion is indicated, the necessary blood will be found at time of operation in the peritoneal cavity. We always have an autotransfusion set available.

The postoperative course of the patients in this series was complicated in five by paralytic ileus. This was transient in one patient (Case 10), persistent in another (Case 11) and of three to four days' duration in the others. The patient with the persistent ileus also had a febrile and stormy course for almost a week.

The convalescence of the remaining eleven cases was smooth and unattended by any difficulty. There was no mortality.

SUMMARY

A statistical review has been made of sixteen cases of "pure" rupture of the normal spleen, i.e., unassociated with other injury, and an attempt made to correlate the findings diagnostic of this syndrome.

These cases have not been reported heretofore and are added to the literature.

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DISCUSSION OF PAPERS BY DRS. SCHAER, DZIOB AND BROWN, GLAS, MUSSELMAN AND CAMPBELL, CHRISTENSEN, IGNATIUS AND MATHEWSON, AND MANSFIELD

Roswell K. Brown (closing): The patient that Dr. Schaer presented in his paper was brought into our trauma conference on foot nine days after his injury. The patient was a farmer who had been butted by a bull and who had some marks on the left side of his trunk, with an enlarging abdomen. At that time Dr. Dziob made a plea for peritoneal tap, and on the tenth day this patient was operated upon.

Many times a peritoneal tap will clear up a diagnostic problem of blunt trauma to the abdomen. I believe this was also brought out in Dr. Glas' paper.

Carleton Mathewson, Jr. (closing): Dr. Christensen has presented our experience with large bowel injuries. I should like to make one or two comments. Dr. Ravdin and Dr. Casberg have emphasized the great importance of the establishment of an organized method of handling civilian casualties in case of a major catastrophe. Fortunately for the citizens of the City and County of San Francisco, such an organization on a minor scale has been in existence in San Francisco for many years. This is known as the San Francisco City and County Emergency Service and consists not only of a well trained ambulance service but also of a number of emergency hospitals operated by the City and County of San Francisco which are distributed throughout the city. In each of these hospitals there is a surgeon, a nurse, an ambulance driver and a steward on continuous duty throughout each twenty-four-hour period. The citizens of San Francisco have learned to report all acute emergencies to this service. Patients are brought by City ambulance to the nearest emergency hospital where they are given emergency treatment and then either referred to their private physicians or taken to the Mission Emergency Hospital, which is part of the San Francisco City and County Hospital, for definitive care. At the Mission Emergency Hospital there is in attendance at all times a resident surgeon from either the Stanford University or the University of California service. All patients entering here are placed immediately under the jurisdiction of either the Stanford University or the University of California Surgical Service.

All of these patients reported by Dr. Christensen entered our service through the Mission Emergency Hospital and therefore received almost immediate

attention. This factor more than any other, I believe, has contributed to the very low mortality.

All of us who had World War II experience were taught not to perform closed amputations, to treat all compound fractures by open methods, and to treat all wounds of the large bowel by exteriorization or by closure and proximal colostomy whenever possible. These rules no doubt saved countless lives during that conflict. Our experience has shown that these rules are not always necessary in civilian practice, particularly when patients are seen early and remain for the entire period of treatment under the supervision of the same surgeon. Under these conditions many amputations may be closed primarily, many compound fractures treated by closed methods and many large bowel injuries closed by primary suture without proximal colostomy.

DONALD S. THATCHER (Milwaukee, Wis.): In our office Drs. Irwin Schulz, Paul Hausmann and I have had experience with seven cases of traumatic rupture of the spleen in the last five years. These have divided themselves into four cases of immediate rupture with hemorrhage, and three cases of rupture with delayed hemorrhage.

There were varying degrees of trauma from various sources in the four cases with immediate rupture. Two of these patients had no external evidence of serious trauma on the trunk. All had positive abdominal findings of left upper quadrant tenderness with some degree of rigidity, and some had rebound tenderness.

The x-ray findings were significant in all four of these cases. In one they were only suggestive of some beginning abdominal ileus. The period between injury and the time of definitive surgical treatment by exploratory laparotomy varied in the immediate series between six and twenty-seven hours, and three of these four patients were found to have free blood in the peritoneal cavity.

Four patients showed delayed signs of hemorrhage from rupture of the spleen. They varied from nine to sixty-four years of age, and again all three patients showed evidence of pathologic disorder in the left upper quadrant. The x-ray was negative in one and showed associated traumatic lesions and evidence of left upper quadrant disorder in two. The interval between injury and operation varied from five to ten days, and in one of these cases there again was free blood in the abdominal cavity at operation.

We believe that x-ray can be of great aid in the diagnosis of traumatic rupture of the spleen, and we look for one or more of these signs: enlargement of the splenic shadow, indicating intracapsular hemorrhage; obscuration of the splenic shadow which usually indicates perisplenal hematoma; elevation and fixation of the left diaphragm; pleural effusion or atelectasis, if the condition had been present for some period of time, or contusion of the lung from associated fractured ribs.

All or several, or only one or two of these signs may be present in any given case: evidence of fractures of the left lower ribs, distention of the colon or the stomach with pressure defects in the air shadow, and intestinal ileus which may be of varying degree, of course. However, they do give fairly accurate leads to the fact that there is a traumatic lesion in the left upper abdomen.

One of our patients was a nine year old boy with delayed hemorrhage from a ruptured spleen. Because of the difficulty of diagnosis, a barium enema was given and gastrointestinal series were done during observation in the hospital, giving us an unusually good picture of some of the x-ray findings: the indentation of the greater curvature side of the stomach, suggestion of enlargement of the spleen shadow and abdominal displacement of the splenic flexure.

Another plate of the abdomen showed distention of the colon and a medial displacement of the greater curvature of the stomach. There were fractured ribs in the left lower chest wall and beginning ileus in the small bowel.

Of the seven cases that we had, the x-ray findings were positive in five, suggestive of left upper quadrant pathology in one and grossly negative in another.

Four of the cases presented free blood in the abdominal cavity at the time of laparotomy. Of these four, three showed a significant degree of anemia in the preoperative blood count. Therefore we believe that if there is a significant degree of anemia it indicates there may be rupture of a subcapsular hematoma and actual free blood in the peritoneal cavity.

All of our patients except one were operated upon within two to three hours after admission to the hospital. The nine year old boy mentioned previously was observed for a period of four days before the positive diagnosis of rupture of the spleen was established.

We found that our experience so far conforms fairly well with that reported in the literature. Approximately 14 per cent of all splenic injuries will exhibit delayed hemorrhage; and if this delayed hemorrhage occurs, 50 per cent will occur within the first week and 25 per cent after the first week.

We rely rather consistently upon x-ray findings to augment the clinical diagnosis of traumatic rupture of the spleen. There was no mortality in this series of seven cases.

CHESTER C. GUY (Chicago, Ill.): I would like to comment briefly on the problem of the ruptured spleen, and to raise a question. It is the general teaching that with evidence suspicious of a ruptured spleen exploratory laparotomy should be

carried out, and that the mortality from a ruptured spleen, if unrecognized and when splenectomy is not performed, approaches 100 per cent.

In operating on the stomach, colon or diaphragm I think most abdominal surgeons have had the experience of accidentally making a tear in the capsule of the spleen. I know I have done so. If the tear is of a minor nature, it is usually controlled by packing. If, of course, it is extensive or it involves the hilar area, it is usually necessary to perform splenectomy to control the bleeding.

This suggests the question as to whether traumatic ruptures of the spleen do actually ever heal spontaneously. At autopsy the pathologist frequently finds extensive perisplenic adhesions, scars of the capsule and even deep scars of the parenchyma of the spleen. He generally attributes these abnormalities to some pre-existing disease, such as infection, splenic infarcts or other lesions. Yet he may admit that in the rest of the body he finds no explanation for the source of such an infection, or the source of any emboli.

On more than one occasion when I have seen such findings at autopsy, I have tried to determine if there was any evidence or history of an injury to the patient which might have caused the spleen to rupture and heal spontaneously. I have searched for old fractures of the left lower ribs and other evidence of trauma in the abdomen or chest. So far my search has been unsuccessful.

I would like to ask if anyone has ever seen a proved traumatic rupture of the spleen which healed spontaneously. We teach our residents and students that rupture of the spleen, actual or suspected, should be investigated by exploratory laparotomy. I have no question whatsoever of the wisdom of this teaching, but I wonder if there are some exceptions.

I might even suggest that if this question is of interest to anyone with facilities for animal experimentation, it might be studied by such methods.

Brooke Roberts (Philadelphia, Pa.): The Notre Dame team physician told me that for the last two years he had had only two serious injuries on the team, last year, a concussion and this year the injury discussed herein.

As Dr. Ravdin said, this patient did not come into the hospital until after midnight of the day of the game. He continued to play after the injury, was taken out when the second team was put in during the third quarter, continued to watch the game, and then took a shower after the game without any apparent difficulty.

When questioned, he said there was some tightness in his abdomen but not much in the way of pain. The first pain he had was when he was putting on his shoes after the game. When he bent over he had severe pain which continued and gradually increased as he became progressively weaker.

I think it is of considerable interest that at the time we operated on this man, we recovered over 3,000 cc. of free blood from his peritoneal cavity, giving some indication of the magnificent physical specimen he is. His pulse was 80 at the time he came into the hospital, his blood pressure was down to 80 over 60, but he was not in deep shock. He was not sweaty, cold nor did he show any of those signs and yet he had bled over 3,000 cc. into his peritoneal cavity. I am happy to report he is doing well at the present writing.

Frederic Wolcott Bancroft (New York, N. Y.): Max Saegesser of Berne has shown that when the spleen has been ruptured, if one puts digital pressure over the scalenus anticus muscle, pain will be elicited on the left side. This is due to the fact that the phrenic nerve sends fibers over the spleen and they are affected in rupture of the capsule.

There are two radiologic tests that will help us with rupture of the spleen. If a barium swallow test is given and the patient placed in Trendelenburg position, the barium will gravitate to the cardia; and if there is a space between the barium in the cardia and the diaphragm, it is obviously free fluid which is most apt to be blood from a ruptured spleen. Needle biopsy will also verify this fact. The reverse is true—that if the patient is given a sedative powder which creates gastric gas and is placed in the erect position, the gas in the cardia of the stomach will be separated from the gas in the diaphragm by a blank space. We had a child at the New York City Hospital who had rupture of the spleen with delayed hemorrhage. The Trendelenburg position and barium in the stomach revealed the diagnosis, and immediate operation saved the youngster.

Fraser N. Gurd (Montreal, Canada): In discussing Dr. Christensen's paper it might be well to emphasize that the mechanism producing a wound of the colon may have some bearing upon treatment. The majority of Dr. Christensen's cases were due to penetrating wounds from knives or bullets, whereas in Montreal we would see a much higher percentage of tears due to blunt trauma such as occurs in automobile or industrial accidents.

Injuries due to blunt trauma are much more likely to show major tears in the mesenteries, greater soiling and more extensive retroperitoneal hematoma. The viability of bowel may be more compromised; the tendency to postoperative ileus is greater. Such injuries must be treated more conservatively with some form of exteriorization usually being advisable.

I would like to congratulate Dr. Christensen on this remarkable series, but also point out that the high percentage of penetrating wounds renders

the group more than usually adaptable to primary closure.

CHARLES HUGH MAGUIRE (Louisville, Ky.): I was particularly interested in the paper on bile duct rupture, since a very casual injury allowed me to perform an easy cholocystectomy. A young, lean boy in his twenties, while working in a lumber yard, ran around a corner and into a 4 by 4.

Two hours later he was in the hospital with moderate abdominal discomfort, signs of fluid in his flanks and in moderate shock. We knew that something was wrong internally and so we operated.

The patient had 1,000 or 1,200 cc. of blood-tinged fluid in his peritoneal cavity, and threading his intestinal tract. Thinking he might have had intestinal injury, we sucked out the cul-de-sac and brought up the suction tip, to which the gall-bladder was attached. We explored around the common duct and found the cystic artery thrombosed, and the stump of the cystic duct. A very trivial bit of trauma can give this type of injury.

I was also interested in the paper on liver injury, because several years ago Drs. Sanders, Moore and myself presented several cases of massive rupture of the liver. One patient was a boy who had been caught under the windshield of a jeep when it skidded under the back end of a trailor truck. The entire dome of the right liver had literally exploded. On operation we removed as much liver as we thought we should, put in packs, administered about 10 pints of blood and autotransfused two or three more.

Ten days later the patient started to bleed again. We operated, removed an additional amount of devitalized necrotic liver and put in some more packing. Two weeks later bleeding started again.

We reoperated but could not keep up with his blood loss. Two weeks later bleeding started again. This time we used a thoraco-abdominal approach, went down on the dome of the liver and again removed more dead necrotic liver. When we finished, practically all of the right lobe was gone. Fortunately, the patient survived. During his hospital stay he had received about 80 pints of blood, plus 20 units of plasma.

The question I wanted to ask is: when you débride these crushing injuries of the liver, how do you know when to stop? How do you know how much to take out? How much do you leave? Do you go through normal healthy-looking liver? Although the first liver we left in our patient looked healthy, it obviously wasn't because he bled a second, third and fourth time. How can we be sure of how much injured liver to remove with massive liver injuries?

Surprisingly enough this man is alive and well. We had him back into the hospital some six months ago and his liver functions are perfectly normal. As far as we can tell the left lobe has taken over and he is doing perfectly all right.

HOWARD E. SNYDER (Winfield, Kan.): It was my privilege some time ago to see one of these cases presented in San Francisco by Drs. Mathewson and Christensen, in which they had returned a sutured wound of the large bowel to the abdomen without performing proximal colostomy.

I would like to repeat a remark which I made then. I think it is a fine thing for these men to proceed with this study and to see what their results will be in a large series of cases. However I believe now, as I did then, that their series is not large enough for us to accept it as good principle to return the large bowel to the abdomen after suture in all cases.

Of course, there are only eight cases in the series of twenty-one they presented in which this was done, and they said they thought in retrospect it might have been performed in seven others.

Other points have been brought up by other discussers that the type of injury and the degree of injury, not only of the bowel wall itself but to its mesentery, must be taken into consideration. Certainly, the wonderful results in these twenty-one cases are dependent upon the fine surgical judgment which was exercised in selecting the surgical procedure.

The fact remains that some of those patients with injuries of the large bowel and an unprepared colon should be exteriorized.

I also should like to discuss the other papers in this interesting group. The point brought out about drainage of wounds of the liver is certainly an excellent one. This is a good time to emphasize another point. In those thoraco-abdominal wounds in which the liver is injured, it is most important to close the diaphragm securely and use subcostal drainage.

The type of drainage has been the subject of considerable discussion in wounds which are not so large; a handful of Penrose drains, or a few very large Penrose drains with gauze protruding from the inner end, can often be used as an effective pack and are much more easily withdrawn than the gauze pack.

The question as to whether a wound of the liver should be sutured when a dead space will be left within the liver is debatable I think. In my opinion it is wiser not to suture those, but to leave the liver wound open so that the wound may drain from its depths.

I was very glad that Dr. Brown told us the patient walked into their trauma clinic on the ninth day, and that they had him only twenty-four hours when they explored his abdomen. I should like to agree with those who say that peritoneal tap is of some diagnostic value, but

I should also like to point out that there is probably still what we call an acute surgical condition of the abdomen, and that clinical judgment should perhaps lead us to explore some of these cases early, even though peritoneal taps, x-ray studies and other procedures may be negative.

W. W. GLAS (closing): I would like to answer Dr. Maguire by saying that we have no way of knowing how much liver to take out. I am sure you have the same problem. In general, with large injuries to the liver, we have placed a rubber-shod clamp on the hepatoduodenal ligament and ligated the larger blood vessels and bile ducts. Following removal of the clamp, the smaller vessels are ligated. Those portions of liver that do not bleed are removed when possible. That is not the entire answer. We have had difficulties with postoperative hemorrhage also.

With regard to the problem brought up by Dr. Snyder, we have had some patients, as I mentioned, in whom we did not close the liver wounds. However, we now believe that if we provide adequate intrahepatic drainage to the lacerations we can feel secure in closing those portions of the liver.

ROBERT D. MANSFIELD (closing): I would like to thank Drs. Thatcher, Guy and Bancroft for their discussions. I did not read the portion of my paper dealing with treatment because it would have extended the time too much. All cases were splenectomized and there was no mortality.

Acute Injuries to the Diaphragm

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IN this era of multiple severe injuries it is very easy to overlook or disregard some of them; acute injuries of the diaphragm fall into this category. The persistence of shock in such cases, despite all efforts to combat it, may be explained by displacement of the heart due to the presence of abdominal viscera in the thorax. The deterioration of the patient's general condition may result from the distended stomach or intestines compressing the lung and causing a shift of the mediastinum. Unless the causes for this altered cardiorespiratory physiology are accurately determined and effective measures used to combat them, the outcome is usually fatal. However, there are some survivors who live to have traumatic diaphragmatic hernias diagnosed and repaired months to years later. Our concern in this paper is with the acute injury and how best to diagnose and treat it. A high index of suspicion is necessary.

The material for this report consists of thirty-three patients admitted to Detroit Receiving Hospital between the years 1947 to 1953. Our classification of pathology is based upon the type of injury. There were seven cases of non-penetrating wounds of the diaphragm and twenty-six cases of penetrating wounds of the diaphragm. The latter consisted of six gunshot cases and twenty stab wounds of the thorax. There were only two women in the entire group. The average age was thirty-six years; the youngest patient was four years old and the oldest was sixty-eight years of age. There were nineteen Negroes and fourteen white patients.

Initial Treatment. Initial treatment was carried out in the Emergency Room, and consisted of measures to combat shock, stop hemorrhage and tamponade sucking wounds. The patient was then thoroughly examined. Levin tubes, thoracentesis, abdominal taps and bladder catheterization were used as needed for diagnosis or therapy. (Fig. 1.)

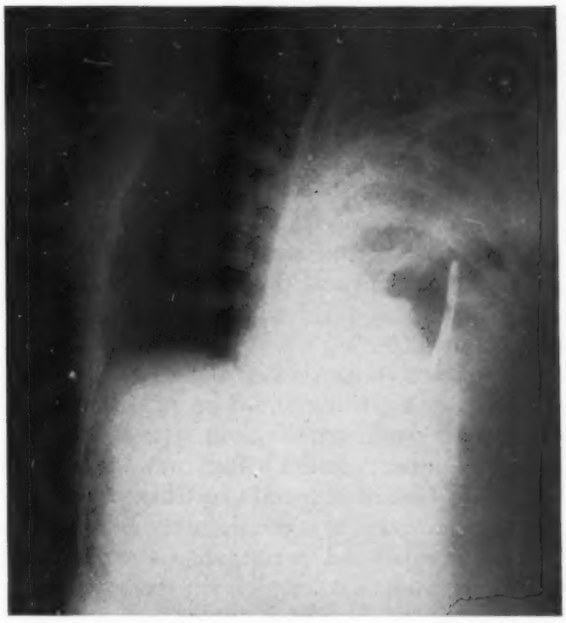


FIG. 1. Ruptured diaphragm, demonstration by Levin tube of intrathoracic displacement of stomach.

NON-PENETRATING WOUNDS

All seven patients with non-penetrating wounds had been severely traumatized and were in shock upon admission to the hospital. Two, as pedestrians, had been hit by trucks, four had been riding in automobiles, and one backed out of a third floor window holding a highball.

Initial physical examination and x-rays disclosed a formidable list of thoracic and associated injuries. Six patients had fractured ribs. Two patients had only one rib fractured while four patients had four to ten ribs fractured. Subcutaneous emphysema was present in three patients, pleural effusion in three, pneumothorax in two and a fractured clavicle in one. Rupture of the diaphragm was initially suspected and later confirmed in four patients. Associated injuries on admission were: fracture

of the extremities (in four patients), seven; fracture of the pelvis, four; rupture of the urinary bladder, two; fracture of the skull, one.

Diagnosis. A diagnosis of ruptured diaphragm was made within a few hours after admission in four cases. While in the Emergency Room, a Levin tube had been passed into the stomach in three patients and was most helpful in correctly interpreting the roentgenograms. In two cases an incorrect diagnosis of pneumothorax was made by x-ray and thoracotomy tubes were inserted. Not until gastric contents were seen coming through the thoracotomy tubes was the true condition realized. In one of these cases the diagnosis of rupture of the diaphragm was not made until the twelfth hospital day. The remaining patient was in delirium tremens when admitted and a rupture of the diaphragm was not recognized until after a review of his x-rays on the sixth hospital day.

Course and Operation. The rupture of the diaphragm was repaired in three patients within eighteen hours after admission. All three had severe associated injuries. Surgical intervention was chosen only after every effort had been expended to improve their general condition and further delay seemed unwarranted. Two of these patients had a rupture of the urinary bladder which was repaired through a small abdominal incision. A transthoracic approach was used to return the undamaged viscera to the abdomen and repair the diaphragm. Both patients were improved postoperatively. One patient, a four year old child, died very suddenly twenty hours later while the surgical staff was visiting her. An autopsy did not reveal any cause for her death. The other patient, a forty-four year old man, died on the fourth postoperative day. Pulmonary secretions could not be controlled despite repeated bronchoscopies and frequent intratracheal suction. He was confused, disoriented and uncooperative, and was unable to cough or help in raising his secretions. Perhaps a tracheotomy should have been done.

The third patient who was operated upon early had been severely traumatized. In addition to multiple rib fractures he had an avulsion of his abdominal wall, and lacerations of the spleen, transverse colon and jejunum. A thoracoabdominal incision was used. The spleen was removed, the lacerations in the intestines were closed and the diaphragm was repaired. The patient died six hours after admission. Probably his shock had been treated too vigorously, as he received a large amount of blood and fluids in a relatively short time and there was evidence of pulmonary edema before death.

In another patient, originally diagnosed and treated for pneumothorax, repair was done forty-eight hours after admission. He did not have any associated injuries; his postoperative course was uneventful and he was discharged from the hospital eighteen days after admission.

Another patient admitted in delirium tremens had a fracture of his elbow, a fractured pelvis, multiple fractured ribs and hemopneumothorax. He was treated initially with intercostal nerve blocks and a thoracotomy tube attached to a water-sealed drainage bottle. The presence of abdominal viscera in the thorax was suspected from a chest x-ray taken on the sixth hospital day. This was confirmed by a barium enema. An immediate transthoracic repair was done with a good result.

Although a diagnosis of ruptured diaphragm was made upon admission in a sixty-eight year old man who also had multiple rib fractures and subcutaneous emphysema, no attempt was made to repair the diaphragm until the sixteenth day because of the wet lung and electrolyte imbalance. A good result was obtained.

The last patient in this group was admitted with fractures of the leg, clavicle and ten ribs. He was treated with intercostal nerve blocks and frequent thoracenteses. Since after four days he continued to have significant paradoxic movement of the chest wall, wires were inserted around four ribs and traction was applied. Periodically, he had acute respiratory distress which was relieved by aspiration of bloody fluid. Despite frequent thoracenteses the fluid continued to form and finally a thoracotomy tube was inserted and attached to a water-sealed bottle. The paradoxic respiration improved and the patient was more comfortable. Fourteen days after admission all of his x-rays were reviewed because of recurrent shock. For the first time a suspicion of ruptured diaphragm was raised, but the diagnosis was not definitely made. The following day the drainage from the thoracotomy tube was fecal. The patients condition rapidly became worse and he died of an unrecognized rupture of the diaphragm, strangulated bowel and wet lung.

PENETRATING WOUNDS

Gunshot Wounds

Gunshots accounted for six penetrating wounds. All patients were admitted shortly after wounding and were in shock. Again, the treatment in the Emergency Room consisted of measures to combat shock, stop hemorrhage and tamponade sucking wounds. Routinely, either a Levin tube or a long tube was passed into the stomach, but blood was aspirated from only one patient. The patient was then thoroughly examined, particular attention being paid to the location of the wounds of entrance and exit. All wounds of entrance were anterior; two were on the right side and four were on the left side. The highest wound was through the fourth interspace and the lowest was just above the xyphoid. All but one patient had wounds of exit and they were between the eighth and tenth posterior interspaces. One patient had pieces of liver extruding from his anterior wound, and omentum protruding from the tenth posterior interspace.

By reconstructing the pathway of the missile and the structures probably traversed, a better understanding of the extent and severity of the injury was obtained. Additional information was obtained from roentgenograms taken shortly after admission to the hospital. Four patients had hemopneumothorax and two had pneumothorax. Free air was seen beneath the diaphragm in one patient, and in another instance the diaphragm was elevated.

Operation. Only after the patient's general condition was improved and shock had been adequately treated was surgery undertaken. The optimum time varied from three to seven hours. In one case operation was two hours later, and in another it was three hours. Three patients were operated upon seven hours after admission. A segment of the ninth rib was removed, the blood present was evacuated from the pleural space and the diaphragm was inspected. If there was evidence of diaphragmatic injury, it was incised sufficiently to permit exploration of the subdiaphragmatic space. Perforations of the stomach and intestines were closed, lacerated spleens were removed and lacerations of the liver were sutured or packed with oxycel. Two splenectomies were necessary. In one instance a patient was admitted with a wound of entrance just above and medial to the left nipple, and wound of exit in the eighth posterior interspace. He was treated conservatively, but because of recurrent episodes of hypotension thoracotomy was performed on the fourth day after admission. Two perforations of the diaphragm were found and a lacerated spleen removed. All perforations of the diaphragm were closed with interrupted sutures.

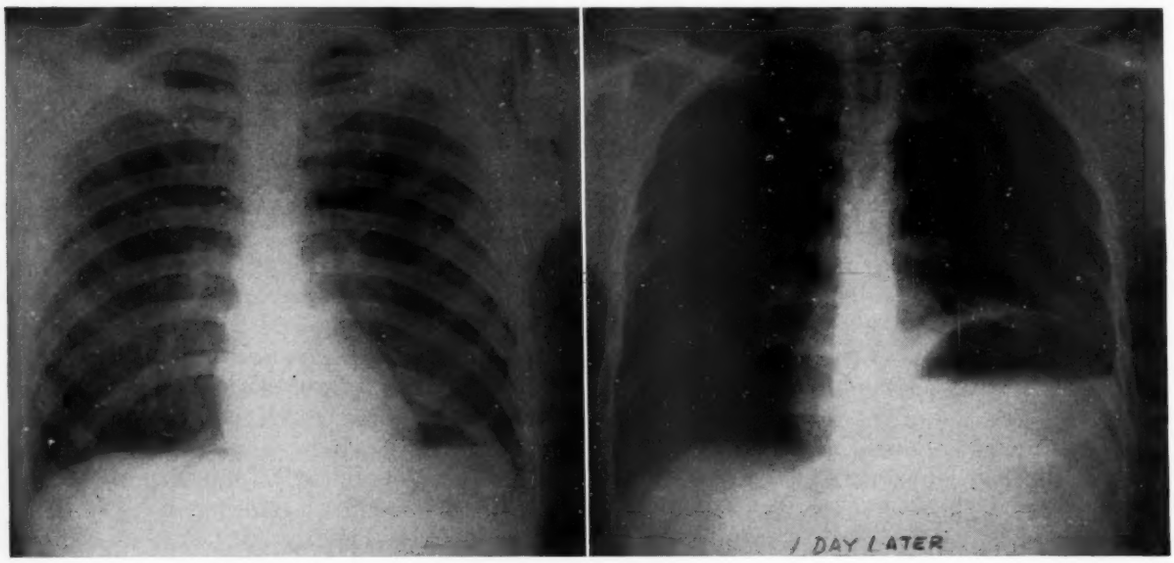
Complications. In three patients there were significant complications. Wound disruption and empyema occurred in the only patient explored through a subcostal incision. Secondary closure of the abdominal wound and drainage of the thoracic empyema prolonged the hospital stay but did not impair the result. There was one death from meningitis and transverse myelitis resulting from a bullet lodging in the spinal canal.

Stab Wounds

There were twenty stab wounds of the chest during this period with significant involvement of the diaphragm, seventeen involving the left and three the right side. Their management on admission was similar to the previously outlined therapy, with the added advantage of the location of the wound arousing suspicion. These were verified in many instances by digital examination of the wound. In general, these patients were in better condition than the previous groups and this facilitated their handling and work-up.

Of the twenty cases, the absolute diagnosis of laceration of the diaphragm was made without the benefit of x-ray in ten cases (six had abdominal content extruding from the wound and in four additional cases the laceration in the diaphragm was palpated). Although indicated in only ten of the twenty cases, x-rays were obtained in fifteen cases for diagnostic purposes or for extenuating circumstances. In view of the sucking nature of most of the wounds and the digital examination that was performed, we were surprised that the x-rays were interpreted as normal in ten patients. (Fig. 2.) In the remaining five, there was elevation of diaphragm in one patient, hemothorax in one, pneumothorax in one, viscera in the chest in one, and pneumohemopericardium in one.

Operation. Fifteen of these patients were explored through a thoracic incision, removing the eighth or ninth ribs. Three were explored through an abdominal incision. In two the



2A 2B

FIG. 2. Stab wound, left thorax. A, apparent normal appearance of admission x-ray. B, subsequent x-ray showing elevation of gastric air bubble.

exposure obtained by the abdominal incision was inadequate and the operation was completed through a separate thoracotomy incision.

In addition to these abdominal injuries there was associated injury to thoracic content in various instances including lung, heart, pericardium and internal mammary vessels.

Results and Complications. There were no deaths in this group. The shortest hospital stay was five days and the longest thirty-five days, with an average of 11.5 hospital days. As evidenced by the relatively short hospital stay, most of the cases were without complication. The complications that were encountered were interesting, as they ran the gamut of surgical experience for both abdominal and thoracic procedures. The ones of note included cardiac arrest and a case of lower nephron nephrosis, both successfully treated.

CONCLUSIONS

In the study of this series of cases our attention was called to the following points which we think should be re-emphasized: 1. A Levin tube is of incalculable aid in interpretation of x-rays.

2. The interpretation of admission x-rays as being negative (especially in stab wounds) leads to a false sense of security. This should be followed by serial films which will be interpreted as a unit. Elevation of the gastric air bubble may be an early sign of diaphragmatic injury.

3. Digital examination should be made of all wounds (especially stab wounds) when possible.

4. Reconstruction of the pathway of a missile gives the best clue as to the extent and severity of the injury.

5. The time of operation is best delayed (especially in non-penetrating wounds) until the patient's condition is well stabilized. Operation should be performed early only when existing circumstances make it mandatory.

Addendum: Since this study was completed, three patients with non-penetrating wounds of the diaphragm have been successfully treated and discharged from the hospital.

Experiences in the Management of Abdominal and Thoracoabdominal Injuries in Korea

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WAR wounds of the abdomen were treated by rest and sedation until World War I. At that time routine laparotomies for exploration of the abdomen were initiated. Remarkable advances were made during World War II, and the presently accepted technics of surgical management for abdominal wounds were then formulated.

It is the purpose of this report to record experiences in the management of abdominal and thoracoabdominal wounds at one forward surgical hospital in Korea (46th Mobile Army Surgical Hospital). During the last three months of the conflict a careful study was carried out on the evacuation, resuscitation and surgical care of all patients who had abdominal and thoracoabdominal injuries. Upon cessation of hostilities a survey was made of such injuries, compiling results from records available at the hospital for the last eighteen months of the war. The hospital was located on the eastern front about 10 miles behind the main line of resistance. It was built of tropical shell construction, with concrete floors, and remained in the same position for the last six months of the war.

TABLE I
REGIONAL DISTRIBUTION OF WOUNDS IN PATIENTS WOUNDED IN ACTION*

Region	Percentage before Body Armor	Percentage with Body Armor
Head and neck	17.4	16.7
Thorax	19.0	8.7
Abdomen	11.0	10.8
Upper extremity	25.0	28.3
Lower extremity	27.0	35.0
Genitals	0.6	0.5
Totals	100.0	100.0

* Adapted from Holmes, Enos, and Beyer.[3]

Incidence of Abdominal and Thoracoabdominal Wounds. The regional distribution of wounds, as compiled from examination of patients wounded in action, is shown in Table I.[3] Before the armored vest was used in Korea, 19 per cent of the wounds of the body were in the chest and 11 per cent in the abdomen; thus 30 per cent of all wounds were in the trunk. There was a decrease in trunk wounds when the armored vest was used, particularly in the thoracic group (8.0 per cent), but wounds in the abdominal regions still totaled 10.8 per cent of all battle casualties. Experiences cited in this report extended over the period in which almost all soldiers wore armored vests.

TABLE II
MODE OF EVACUATION AND TIME INTERVALS

Category	Abdominal Wounds	Thoraco-abdominal Wounds
Total patients	75	29
Evacuation:		
Ambulance	40	19
Helicopter	27	8
Not stated	8	2
Time (hr.):		
Injury to admission	3.1	4.7
Admission to surgery	3.2	2.7
Operative time	2.4	2.3

Evacuation. The mode of evacuation and time intervals for the management of abdominal and thoracoabdominal injuries are outlined in Table II. A study was made of seventy-

five patients who had abdominal injuries and twenty-nine patients who had thoracoabdominal injuries during the final three months of the conflict. Fifty-nine of these patients were evacuated by ambulance, thirty-five by helicopter, and in ten the mode of evacuation was not stated. The battalion surgeon decided when a helicopter was to be used. The helicopter was utilized to evacuate the most urgent cases.

TABLE III
CAUSES OF DEATH

Abdominal 75 cases, 9 deaths	Uncontrolled hemorrhage	5
	Peritonitis	2
	Aspiration pneumonia	1
	Pancreatitis	1
Thoracoabdominal 29 cases, 3 deaths	Uncontrolled hemorrhage	1
	Postoperative shock	1
	Cardiac arrest	1

In the patients with abdominal injuries the average time from injury to admission to the hospital was 3.1 hours. The average length of time from admission to surgery was practically the same. This was the time usually required for preparation of the patient for surgery. On the other hand, when the casualty flow was heavy, several patients had to wait an additional hour until operating facilities were available. Among the patients sustaining abdominal injuries the average time from injury until operation was 6.3 hours. For patients with thoracoabdominal injuries the average time interval from injury to hospital admission was slightly longer. This difference was probably due to a greater number of casualties being evacuated by ambulance. The average length of operation in both abdominal and thoracoabdominal groups was slightly more than two hours.

ABDOMINAL WOUNDS

Results of Three-month Study. In the study group of seventy-five patients who had abdominal wounds there were nine deaths, a fatality rate of 12 per cent. (Table III.) Five of these patients died from uncontrolled hemorrhage, two died from peritonitis and one each died from aspiration pneumonia and pancreatitis.

Two of the patients who died of uncontrolled hemorrhage died during operation. In one patient the common iliac artery was severed. He had a large retroperitoneal hematoma. Upon opening the peritoneum over the hematoma, active bleeding was uncontrollable; suddenly the patient became quite hypotensive and died even though large quantities of blood were infused. This patient received 19 pints of blood in four hours. One patient died of cardiac arrest following prolonged hemorrhage. Operation upon this patient was delayed for ten hours because of the heavy casualty load.

The three other patients who died of uncontrolled hemorrhage had massive wounds of the retroperitoneal area and lower extremities. They received 40, 52 and 56 pints of blood, respectively, in the first twenty-four hours. These patients had extensive muscle damage in the upper thigh and buttock and it was difficult to control hemorrhage.

One patient died of aspiration pneumonia. During evacuation by helicopter he aspirated vomitus. Bronchoscopy was performed but without improvement. This case points out the clinical significance of emptying the stomach as soon as possible after injury.

Two patients died of peritonitis, both having sustained massive injuries to the cecum. One of these patients had an additional injury to the duodenum, while the other had an injury to the small bowel.

One patient died of pancreatitis. In this instance the patient might have been saved by resection of the tail of the pancreas or better drainage of the area.

Results of Eighteen-month Survey. At the end of the Korean conflict a survey was conducted covering experiences of the final eighteen months of hostilities.[5] Three hundred eighty-four patients sustained abdominal injuries. The fatality rate among these was 8.85 per cent. (Table IV.)

It is interesting to compare results of management of patients in various conflicts. For this reason a search of statistical data was made to find a group somewhat similar to the one in Korea, particularly one in World War II which had experienced a comparable time lag. The Second Auxiliary Surgical Group reported on 1,185 casualties observed between 1942 and 1945 whose average time between injury and operation was less than seven hours.[2] This group of patients was classified according to the number of abdominal organs injured. Table IV shows the comparative statistics of fatality rate for abdominal wounds between

this World War II group and the cases recorded in the eighteen-month survey in Korea. There was a significant difference between the over-all mortality of 8.85 per cent in Korea and 20.51 per cent in World War II.

Although there was little difference in mortality in the slightly wounded group (no organ damage) and the most severely wounded group (four, five and six organ damage), there was considerable difference in the moderately wounded group (one, two or three organs). The significant difference in this latter group and in the over-all fatality rate points out the improved results achieved in Korea.

TABLE IV

COMPARATIVE STATISTICS FOR FATALITY RATES FOR ABDOMINAL WOUNDS BY NUMBER OF ORGANS INJURED

(From Sako et al.[5])

No. of Abdominal Organs Injured	Korea		World War II		Statistical Tests for Significance of Differences
	Operation to Injury (average, 7 hr.)		Operation to Injury* (7 hr. or less)		
	Total Wounded	Per cent Dying	Total Wounded	Per cent Dying	
0	36	2.8	98	5	
1	181	6.6	496	10	Chi square analyzed according to the number of abdominal organs injured
2	102	6.9	402	24	
3	45	26.7	132	42	
4	12	58.3	41	54	gives: $X^2(5) = 6.96$
5	6	16.7	13	92	$0.30 > P > 0.20$†
6	2 } 8	50.0	3 } 16	100	
Totals Averages	384	8.85	1,185	20.51	$X^2 = 26.3$ $P < 0.001$‡

* Second Auxiliary Surgical Group, World War II.[2]

† There is no significant difference between the 2 groups in distribution of number of abdominal organs injured which indicates the 2 series are comparable.

‡ There is a highly significant difference in mortality between the 2 groups.

THORACOABDOMINAL WOUNDS

Results of Three-month Study. In the twenty-nine cases of thoracoabdominal wounds that were studied there were three deaths: one from uncontrolled hemorrhage, one from postoperative shock and one from cardiac arrest. (Table III.) All of the patients died within the first thirty-nine hours after injury. All had wounds of the right diaphragm with associated liver damage.

One patient had an extensive laceration of the liver which was repaired at operation and hemorrhage appeared to be controlled. Several hours after surgery secondary hemorrhage from the liver occurred and resulted in death.

Another patient had extensive injuries to the liver, duodenum and ileum. It was impossible to maintain a satisfactory blood pressure at any time during or following operation. It was thought that continued hemorrhage may have led to postoperative shock and caused death.

The other patient who sustained extensive liver and chest injuries had cardiac arrest during operation. The heart was massaged until normal rhythm returned. Twenty-nine hours following surgery the patient had another cardiac arrest and died.

Results of Eighteen-month Survey. In this survey it was found that 129 patients with thoracoabdominal injuries had been treated during the last eighteen months of the conflict.[5] There were seventeen deaths among these patients, a fatality rate of 13.1 per cent. (Table v.) The fatality rate among 883 patients

with thoracoabdominal injuries was 27 per cent, as reported by the Second Auxiliary Surgical Group in World War II. (Table V.) It is not to be expected that these are similar groups of patients, as information on evacuation time was not available in the World War II

TABLE V
THORACOABDOMINAL WOUNDS

Theater	No. Wounded	Deaths	
		No.	Per cent
Korea, 1952–1953.....	129	17	13.1
World War II, 1942–45...	883	239	27.0

series. It is assumed that the time lag was greater for the World War II group than for the casualties in Korea.

COMMENTS

The surgical technics employed in the management of casualties in Korea were essentially the same as those used in World War II. Considerable emphasis was placed on adequate drainage of all wounds of the liver. Wounds of the colon were exteriorized and wounds of the small intestine were sutured. Wounds of the rectum were treated by drainage of the presacral space and a defunctioning colostomy. As a general rule the peritoneal cavity was not drained except in instances of wounds of the liver and biliary tree or retroperitoneal injury.

In contradistinction to World War II experience, practically no thoracoabdominal incisions were used for thoracoabdominal injuries. In general, the chest was treated conservatively by repeated aspiration, and the abdomen was explored through an abdominal incision.

Uncontrolled Hemorrhage. The chief problem in the management of patients in order to lower the mortality of abdominal wounds appears to be the control of hemorrhage. Uncontrolled hemorrhage from laceration of a major blood vessel or from multiple smaller vessels within the abdomen causes a high percentage of deaths. Wounds of the iliac artery, mesenteric vessels and the vena cava produce real emergencies. There appears to be no effective method for controlling this type of bleeding preoperatively. The accepted treatment is early diagnosis and immediate surgical intervention. Emphasis must be placed on careful observation of the abdomen. When a patient cannot be restored with large quantities of blood and he has a rapidly expanding abdomen, his injury can be diagnosed as a large bleeding vessel requiring immediate exploration. As soon as the bleeding is controlled, the patient should be restored to near normal blood volume before resuming the operation. Frequently a surgeon does not realize the extensive blood loss that follows retroperitoneal muscle injury. Oozing from these areas is difficult to control and concealed hemorrhage may not be recognized.

Factors Contributing to a Lowered Mortality. Evacuation: In the over-all experiences between World War II and the Korean conflict, evacuation time was considerably shorter in Korea. The use of helicopters and shorter transportation lines decreased the average time of evacuation. It might appear that a decrease in evacuation time was responsible for a lowered fatality rate in the hospital. It must be remembered, however, that selective transportation by helicopter and more rapid evacuation permit a larger number of very severely wounded casualties to reach the hospital alive. Evacuation by helicopter also provided transportation with less trauma than by litter jeep or by ambulance.

Stability of the tactical situation: During the latter phase of the Korean conflict, the main line of resistance was very stable. This survey was conducted in a hospital that remained in one location for a year and in another location for six months. The stability of the tactical situation permitted better organization for surgical care. Except in occasional instances, the casualty flow was not nearly as heavy as the flow reported in forward hospitals in World War II; therefore casualties with abdominal wounds in Korea were held for postoperative observation for longer periods than during World War II. Most casualties with abdominal and thoracoabdominal injuries were observed for one week postoperatively before evacuation to the rear. The steadiness of this moderate casualty load permitted more time for preoperative preparation and for detailed postoperative care. These factors had considerable effect upon the lowered fatality rate.

Anesthesia and antibiotics: Trained anesthesiologists and anesthetists were usually

available in the forward hospital. Skilled professional personnel of this type certainly contributed to lowering of the fatality rate. Endotracheal anesthesia was used in all patients who had thoracoabdominal injuries and in most of the patients with abdominal injuries. Induction was carried out with a minimal amount of pentothal®, and anesthesia was maintained with nitrous oxide, oxygen and ether. An adequate supply of modern-type anesthetic equipment was available.

Antibiotic therapy was given to all patients who had abdominal and thoracoabdominal injuries. Many of the patients received penicillin prior to admission, and both penicillin and streptomycin were given intravenously to all patients with abdominal and thoracoabdominal injuries as soon as they were admitted. These antibiotics were continued after operation unless a change to broad spectrum antibiotics was indicated by the patient's course. Whenever the patient's clinical course showed signs that penicillin and streptomycin were not controlling the infection from peritoneal contamination, terramycin® was given intravenously.

There were few cases of fulminating lethal peritonitis; however, almost all patients showed a rise in temperature, delayed return of peristalsis and a tender abdomen for several days following operation. There was definite clinical evidence of mild peritonitis, but in most instances spontaneous recovery followed.

Resuscitation: Great emphasis was placed on the restoration of the battle casualty soon after he was injured. Company aid men carried small bottles of albumin in order to begin infusion of a restorative solution soon after injury; in the latter part of the war they also carried plastic bags filled with dextran. Further restoration of the patient was carried out by the battalion surgeon who used dextran to prepare the patient for evacuation. This prehospital resuscitation prevented prolonged periods of hypotension and was responsible for the improved condition of the casualty on admission. Almost all moderately wounded patients received one unit of plasma expander prior to admission, whereas the very severely wounded patients received, on an average, approximately three units of resuscitative fluids.

An analysis of the amount of blood given to the abdominal and thoracoabdominal patients during various phases of care is shown in Table VI. The average amount of blood given to patients in the study group during the last three months of the Korean conflict was 3 pints prior to operation, usually 3 pints during operation and approximately 7 pints during the first twenty-four hours. Many patients required additional blood in the postoperative period.

TABLE VI
UTILIZATION OF BLOOD

Category	Abdominal Wounds	Thoraco-abdominal Wounds
Total patients	75	29
Preoperative	1,464 cc.	1,308 cc.
During operation	1,467 cc.	1,187 cc.
Average, first 24 hr	3,428 cc.	2,867 cc.

For patients with thoracoabdominal injuries the average amount of blood used was slightly less. It was believed that the quantities of blood used in Korea were somewhat higher than those used during World War II. It must be emphasized that at all times during the latter part of the Korean conflict Type O blood was immediately available. Tremendous quantities of blood were required in some patients. One patient who had an extensive wound of the liver received 46 pints of blood in the first twenty-four hours and survived.[1] Several other patients survived after administration of more than 20 pints of blood.

Blood volume determinations by the chromium 51-labeled, red cell method that were carried out in the postoperative period showed that rarely was there evidence of overtransfusion in spite of the administration of massive quantities of blood.[4] In eight patients having abdominal wounds, who received an average of 5,300 cc. of blood, the average blood volume postoperatively was 86.7 per cent of normal. During the preoperative, operative or early postoperative periods continued loss of blood into the tissues or externally seemed to be the reason for this tremendous blood requirement.

Immediate operation was mandatory when hemorrhage was uncontrolled in the abdomen. In other patients blood was given until their blood pressure rose to 110 systolic and pulse rate fell to 120 per minute or less. All patients had Levin tubes inserted prior to operation

and many had an indwelling catheter placed in the urinary bladder. An adequate flow of urine was further evidence that the patient had been adequately restored.

SUMMARY

During the latter part of the Korean conflict a survey of patients who had abdominal injuries and were admitted to the 46th Mobile Army Surgical Hospital showed a mortality of 8.85 per cent. The average evacuation time was 3.1 hours and the time from injury until operation was 6.3 hours. In a comparable group during World War II the case fatality rate was 20.51 per cent.

The fatality rate among patients who had thoracoabdominal injuries was 13.1 per cent as compared with 27 per cent in World War II. Several factors were responsible for this reduction in mortality. The surgical technics employed were essentially the same as those used in World War II but the stable tactical situation in Korea permitted better organization for surgical care and a longer period of postoperative observation. The availability of an adequate number of trained anesthesiologists and anesthestists, together with modern antibiotic therapy, was undoubtedly of assistance in decreasing the mortality. Two of the most effective factors in decreased mortality, however, seemed to be early restoration of blood volume and utilization of larger quantities of whole blood.

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DISCUSSION OF PAPERS BY O'ROURKE AND JACOBSON, AND ARTZ, BRONWELL AND SAKO

R. Arnold Griswold (Louisville, Ky.): I should like to say a word about the first paper and one term that was used. As I recall it, several of these lacerations of the diaphragm were discovered by digital exploration of the wound. I see no reason whatsoever for digital exploration of a wound of the chest, abdomen, extremity or anywhere else. You should open them up and look at them, not explore digitally.

Brian Blades (Washington, D. C.): There is one point which should be made concerning undiscovered diaphragmatic hernias of the traumatic type. We saw a great many of these during the war after they had reached a general hospital. It was not uncommon for these patients to have been subjected to thoracentesis, and this was an understandable error from the standpoint of the appearance of the x-rays. The herniated stomach often gave a false impression of pleural effusion with shift of the mediastinum to the opposite side. When the thoracentesis was performed, the needle would penetrate the stomach. If this occurred, the patient often went into immediate and profound shock.

From the practical standpoint, differential diagnosis is not too difficult. Any patient who has had a penetrating or non-penetrating wound near the diaphragm is vulnerable to tear of the muscle. If after this type of injury a fluid level is seen in the thorax, the possibility of a defect in the diaphragm must be considered, almost with complete disregard of the length of time after the injury.

I believe the late Dr. Fraser Gurd reported an interesting injury to the diaphragm during the last war. This concerned a fighter pilot who after going into a very steep dive suffered a rupture of the diaphragm from the abrupt pressure changes.

Elmer R. Maurer (Cincinnati, O.): I think it has been fairly well established that minor injuries to the diaphragm can subsequently lead to herniations at a much later date.

I thought the Association would be interested in hearing about a rather unusual situation.* This occurred in a forty-two year old white man who presented himself with a lesion, a problem in differential diagnosis. We did not know whether it was a lung tumor or a lesion of the diaphragm or pericardium. From the past history, this man had never had any serious injury. He had been in one automobile accident and had had only a minor contusion of the abdomen.

This man was operated upon, and a portion of the liver had presented through a rent in the diaphragm extending down but not through the foramen. It was necessary to resect this portion of the liver and it was accomplished satisfactorily.

I would like to emphasize something that we mentioned in a paper during the meeting last

*Dr. Maurer illustrated his discussion through the use of a slide.

year, and that is the use of tracheotomy in those instances where one has to deal with an abundance of tracheobronchial secretions. Also, I think it is an invaluable aid in the management of a paradoxically moving chest. Certainly they are brought under immediate control. It eliminates the utilization of fixation and traction, and wires.

Dr. Jacobson's paper certainly points up the observations we have made in the past, namely, the high incidence of associated injuries to the skeleton and other viscera with injuries to the chest.

There are two suggestions that I would like to offer. In those instances where one deals with an avulsion of the diaphragm, where it is literally pulled away from the chest wall, it is usually possible to place mattress sutures and bring them out in a pericostal manner to secure the diaphragm to the chest wall beneath the skin.

Also, if one remembers anatomically that the diaphragm literally is a continuation of the transversalis muscle by merely dissecting anteriorly one can bring up sometimes as much as 3 to 5 inches of tissue to bridge a defect that otherwise could not be repaired.

I certainly go along with subcostal drainage of those lesions which involve injuries to the liver, and I would like to add one other suggestion: If one makes a particular attempt to proximate the peritoneum in those instances, I think a much more solid wound of the diaphragm will be obtained.

I would like to ask one question of Dr. Artz, and that is about his choice of anesthetics in those individuals who came in with rather profuse bleeding into the tracheobronchial tree, obviously candidates for emergency surgery. I will admit this does not happen very often. Personally, we prefer to use pentothal® with rapid intubation so that we have control over the tracheobronchial tree.

CURTIS P. ARTZ (closing): I would like to make one additional comment about the technic of drainage of the abdominal wounds handled in Korea. During the last two years all those wounds of the peritoneal cavity, without retroperitoneal damage and without injury to the liver or biliary tree, were closed without drainage. On the other hand, all those with injuries to any retroperitoneal area, such as the duodenum, kidney, bladder, retroperitoneal muscles and pancreas, were drained.

In response to Dr. Maurer's question, we saw only one patient with severe tracheobronchial bleeding that required immediate tracheotomy. The tracheal tree was sucked out; and when the patient went into the operating room, the tracheotomy tube was removed and an endotracheal tube inserted after rapid induction with pentothal.

Corn Picker Injuries

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INJURIES due to the mechanical corn picker are preventable, usually serious, and cause great loss of function, chiefly because of damage to the hands. Education via farm journals and careful instructions (written in white letters on the machines) not to put hands into the moving parts have not prevented these severe injuries each Fall and Winter. Farmers are prone to accidents because (1) they often work alone with heavy machinery, (2) they have very little training about possible accidents, (3) they use these machines not constantly but only seasonally, (4) they often remove safety devices to facilitate operation, and (5) they too often will not shut off a machine while unclogging or fixing it. Twenty-five per cent of all occupational deaths occur among farmers. Although the corn picker injury is rarely fatal, it is often permanently crippling.

Fewer corn picker hands have been seen at the University of Kansas Medical Center in the past two years than during the preceding five years,[2] possibly because of better education. In the heart of the corn belt, McVay[3] stated that last year he treated only five patients with corn picker injuries instead of the usual fifteen or twenty patients a year. The injuries are usually severe, with a combination of burns, avulsions (Fig. 1A and B), fractures or traumatic amputations, and deep injuries to the vessels (Fig. 2A and B) or bones which require late amputation. (Fig. 3A and B.) Maxim et al.[4] reported twenty-eight, and Young and Ghormley[1] twenty-nine injuries very similar to the type seen at the University of Kansas Medical Center and at the Wadsworth Veterans Administration Hospital.

1A 1B 1C

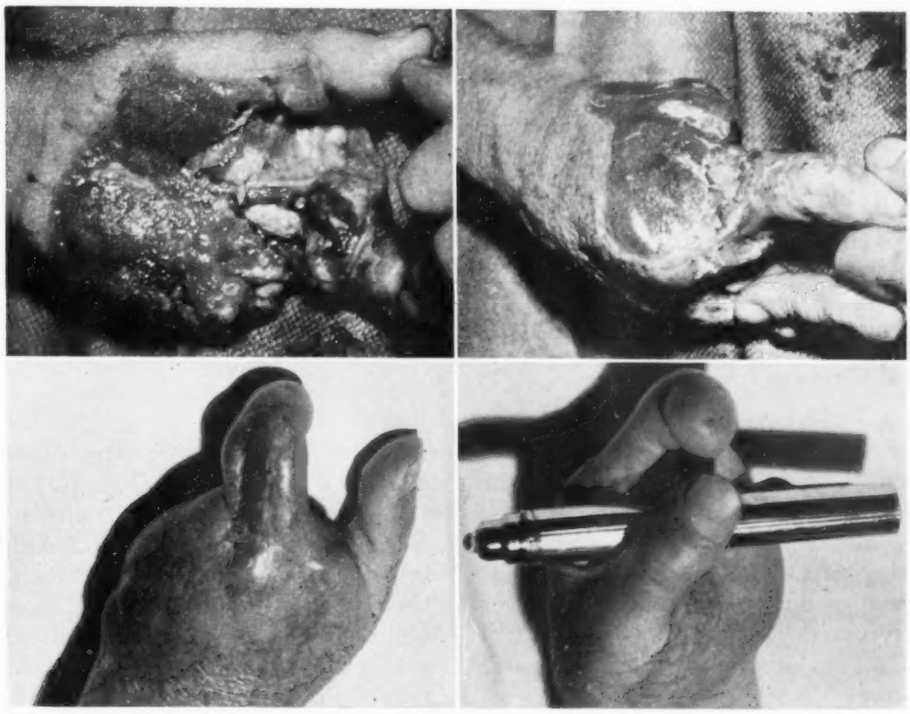
FIG. 1. Case 1. A, complete full-thickness slough of most of back of hand due to friction burn from hand in rollers thirty minutes. B, extensive deep damage with frayed tendons, ground up intrinsic muscles, three digital nerves severed and all digital vessels in spasm. C, abdominal pedicle in palm in hopes of allowing more motion of tendons fixed to scarred skin. Note clumping of fingers due to intrinsic muscle loss.

Of the eighteen patients seen here* in the last five years, only five had superficial losses without some deeper structure seriously damaged. Thirteen had amputations of fingers, hands or forearm. One boy lost his forearm just below the elbow, one lost both hands and one lost all the fingers of both hands. (Fig. 4A and B.) Amputation of the thumb was present in six and the loss of skin of the penis and/or the scrotum occurred in two of these patients. Considerable skin grafting was needed for coverage of the leg and thigh in two patients. In some there was a loss of some skin, but due to the mangling and grinding effect of the deeper injury, the resultant hands were quite stiff, anesthetic in part and non-functional. Extensive tendon injuries, present in ten of the

* Eight of these patients were cared for at the Veterans Administration Hospital, Wadsworth, Kan.

2A 2B 2C

FIG. 2. Case II. A, gangrene of all structures of four fingers five days after injury; common picture seen. B, direct abdominal flap twenty days after its application. Note skin graft covering donor bed and the partial section of the base. C, abdominal pedicle with bone graft inserted for fixed post effect.



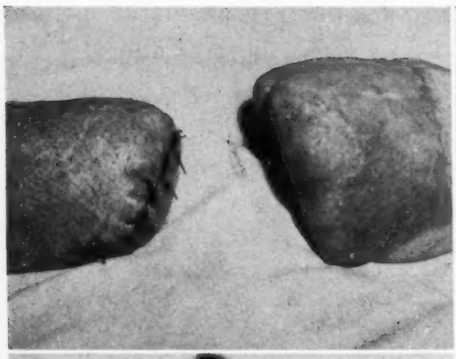
3A 3B 3C 3D

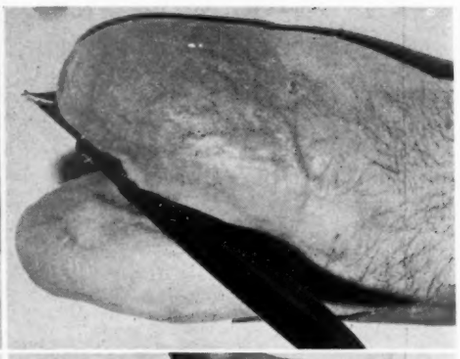
FIG. 3. Case III. A, palm one month after injury; only mid-finger remains. Abdominal flap applied at this time. B, dorsum to be covered by a skin graft at same time as the flap. C, fixed mid-finger as a hook useful for farm work. D, thumb can appose to fixed mid-finger stump. Abdominal pad allows heavy duty.

eighteen patients often without good viable soft tissue coverage (Fig. 5A and B), caused great disability, and extensive damage to the intrinsic muscles produced clumping of the fingers together in a claw-like hand (Fig. 1C) which had very little motion.

Important considerations of early definitive care (rare here as patients come in late from considerable distance) are as follows: (1) complete examination (including neurologic and radiographic); (2) use of a tourniquet, at least early in débridement; (3) minimal débridement with careful removal of dirt, foreign bodies and detached bone only; (4) coverage (for early healing) by wound closure, skin graft or distant pedicle flap. (Fig. 2B.) Length is never sacrificed[5] for closure even though pedicle grafts or skin grafts are used primarily. A severe and

4A





4B

5A

5B

FIG. 4. Case IV. A, bilateral amputee. Useless upper extremities unless there is prosthesis or plastic procedure. B, lobster claw gives good grasp on small objects. Deepening of an interosseous space with skin graft.

FIG. 5. Case V. A, mid-finger fixed in flexion, sensation of finger, dense scar in palm. Injury occurred six months before; tendon fixed in scar. B, filleted finger flap in palm plus full-thickness skin graft cover palm and allow considerably more finger extension and grasping function.

unusual aspect of the corn picker hand injury is the tendency toward late gangrene of the whole part (Fig. 2A) or late necrosis of bone because of damage, often with traumatic spasm of the superficial and deep palmar arches. Various attempts to obtain a better blood flow by vasodilatation drugs or block of the brachial plexus or sympathetics have not been satisfactory.

Great economic loss was produced by prolonged hospitalizations with multiple procedures and permanent loss of earning power caused by the defunctionalization of the hand. Care was often extensive and frequently done in the Veterans Administration Hospital. Late type procedures were indicated, for example: (1) defatting of abdominal flaps on hands; (2) skin grafts for coverage (Fig. 3C); (3) deepening of the clefts between the fingers (Fig. 4B), particularly between the thumb and palm; and (4) rotation osteotomy or arthrodesis of fingers (Fig. 3D) in better positions of function. A lobster claw of the Krukenberg type can be made to hold small or large objects. A finger fixed as a curved hook (Fig. 3D) often is useful for the farm work, and a built-up stump for a finger post (Fig. 2C) or thumb will help the all important opposing function for grasping. Although slow in development, some sensation will return in such stumps built up by pedicle grafts with bone inserted for stability. Pollicization of a finger may be important for the grasping function. The re-repair of digital nerves is important for the return of sensation, but too often dense scar obscures the nerve endings. Defatting of flaps is done more for appearances. If this is done too extensively, function may be further impaired by fixation to the skin.

SUMMARY AND CONCLUSIONS

A study of eighteen injuries produced by the mechanical corn picker reveals the serious extent of the damage, early and late, with very poor functional ability possible by reparative surgery to the hands. Every effort should be

made toward education by pointing out the dangers and great economic loss from these accidents which are completely preventable.

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Injuries to the Hand in Children

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ACCIDENTS in children play an important part in the surgery of trauma in all parts of the country. It has been estimated that yearly 12,000 to 13,000 children are killed, 40,000 to 50,000 are permanently injured and 1 million seek medical care.[1] Injuries to the hand play an important part in these injuries. Although many are minor and death is rare, there are sufficient numbers of severe crippling injuries that permanently disable the child. Many of these are preventable.

TABLE I

Age	No. of Patients
Under 1 yr.	10
1–2 yr.	42
3–5 yr.	51
6–12 yr.	42
13–16 yr.	42

We have reviewed a series of 187 injuries to the hand that have been encountered in children in the last four years. With very few exceptions, all of these were severe enough to require hospitalization.

Of the total number of patients in this series of 187, 111 were male and seventy-six were female. Over half of the accidents occurred in the first five years of life. (Table I.)

The etiologic factors were many and varied. Broken glass was the main offender, while burns was the next common source of injury. Wringer and mangle injuries closely followed the burns. Doors of all kinds (car doors, house doors and so on) also accounted for a substantial number of injuries, while sharp objects such as knives, lawn mowers, etc., followed. (Table II.)

TABLE II
ETIOLOGIC FACTORS

Glass	33	Lawn mower	6
Burn	27	Meat grinder	5
Wringer	13	Automobile	5
Doors	13	Explosive	4
Mangle	12	Ball playing	4
Knife	9	Saw	4

Miscellaneous

Coffee can cover	Ice skate blades
Razor blades	Fan
Corn shredder	Hatchet
Cement block	Escalator

Diagnosis. Diagnosis of hand injuries in children is more difficult to make than in an adult. The small infant is often crying, is frightened and therefore is usually uncooperative, and it is extremely difficult to determine just what injury has occurred. In completely severed tendons in the fingers the diagnosis itself is quite obvious and should cause no difficulty. It has been suggested that the child be allowed to play, fall asleep and then the hand be carefully observed in the position that it falls.[2] If there is any doubt in our mind at all, the infant is taken to the operating room and the diagnosis is made by direct observation under anesthesia.

A thorough knowledge of the anatomy of the hand is important. This is especially necessary in the young child where we are unable to use the usual physiologic tests.

General Consideration. Following an injury to the hand, first aid treatment should consist of the application of a compression type of dressing to control bleeding. On one occasion we have seen a child transferred from clinic to hospital to another hospital, while profuse bleeding occurred from a lacerated superficial volar arch of the palm. With direct pressure on the bleeding area itself, clotting would have occurred and the blood loss halted. Instead, the child actually was almost in extremis and had to be given blood transfusions before surgery could be performed.

Once the examination has been made and it has been decided to admit the child and carry out further surgical procedures in the operating room, a history of the injury must be obtained and physical examination must be carried out. In addition, routine blood count and urinalysis

are obtained. Tetanus toxoid booster injection and antibiotics, if deemed necessary, are also utilized.

The surgical procedures in the operating room should be performed under adequate sedation and anesthesia. We have found that preoperative rectal sodium pentothal® works exceptionally well in sedating the excited child before he is admitted to the operating room.

When the child is asleep, the hand is then thoroughly washed with soap and water for ten minutes. A blood pressure cuff is used as a pneumatic tourniquet. In children the cuff is inflated to 240 to 250 mm. Hg. The procedure is as follows: The arm is adequately padded, the blood pressure cuff is placed over this padding and this, in turn, is held in place by a roller gauze. The arm is elevated for one minute and the cuff is rapidly inflated to 240 to 250 mm. Hg. This cuff may be left on for one to one and a half hours. If it is necessary to operate longer than that time, the cuff is reapplied after ten to fifteen minutes. Adequate exposure of the injured area is obtained by making mid-lateral incisions, that is, on the side of the involved finger. In the palm, incisions are made so that they follow the flexion creases. At the conclusion of the surgical procedure the cuff is deflated, bleeding vessels are clamped and ligated with fine cotton suture material and the skin edges are then carefully closed with interrupted nylon suture.

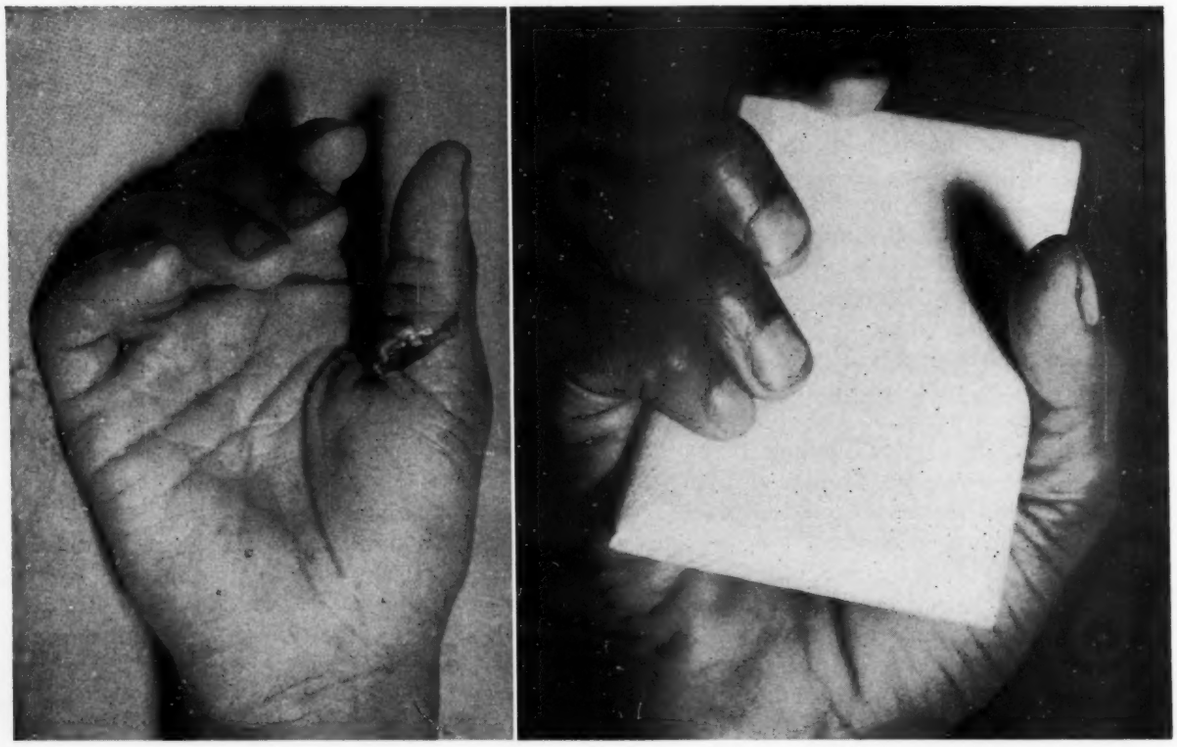
In regard to suture material, fine cotton or silk is used for the tendons, according to the technic of Koch, and fine silk is used for the nerves.

Dressings are fastened securely and adequately. They usually extend from the fingertip to the shoulder. Metal splints can be fastened to the forearm with adhesive tape. A plaster of paris splint can be molded to fit the dressing securely. It is extremely important to obtain adequate immobilization and it is often necessary to use a large bulky dressing that will keep the extremity quiet. "Parents must be instructed to watch over the child. They must be carefully briefed, as to what is required of them and the consequences of neglect. Simply to discharge a patient from the hospital with a note to attend an out-patient clinic in one, two, or three weeks is to court trouble."[2]

The patient is then hospitalized for several days to several weeks, depending upon the procedures used. However, it is often possible to send them home for a few days; but at any time when it is necessary to remove a large number of sutures or if tendon or nerve work, etc., has been carried out, we then think that these patients should be brought back to the operating room and anesthetized. The sutures are carefully removed while the patient is relaxed and cooperative. Here again rectal pentothal® is given on the pediatric ward and works exceptionally well in sedating these individuals preoperatively. Our first dressing is usually at the end of a week for practically all surgical procedures. However, recently it has been suggested that in tendon work the original dressing is to be left on for four weeks, and then the patient brought back to the operating room and the dressing and sutures removed.[2] I think that this longer period of time has considerable merit since on several occasions we have thought that some function had been lost even though the sutures were removed under general anesthesia at the end of one week.

Soft Tissue Injuries. Soft tissue injuries are often encountered in injuries to the hand in children. These range from small minor cuts that can be treated without anesthesia, to severe avulsion lacerations and even amputation of a member of the hand itself. The most common injury encountered is that due to electric power lawn mowers and doors. Here the tip of the finger, soft tissues and portions of the distal phalanx are traumatically amputated. This type usually responds quite well to the application of split-thickness skin graft taken from the upper thigh or forearm. The skin graft is held in place by a stent, usually of moist cotton. A compression type of dressing is applied with a plaster of paris splint extending from the tip of the finger to the elbow. The outer dressing, elastic bandages, etc., extend to the axilla. If too much skin is missing, it is conceivable that a pedicle could be raised from the palm. We have had difficulty, however, in securing adequate mobilization in this type of graft. It is also possible to apply a pedicle graft from the abdomen, incorporate the arm and hand in a plaster of paris support and allow healing to occur.

Care should be taken to preserve as much length of the digit as possible. In an occasional case, when the injury is quite small and skin grafting does not appear to be feasible, a compression type of dressing can be placed



1A 1B

FIG. 1. A, a five year old boy with a laceration of the flexor pollicis longus tendon to the right thumb. Primary repair was carried out under general anesthesia. B, fair function after four months. This patient may be a good candidate for a tendon graft later, but good power is noted in the thumb at this time. A wooden block is used to encourage motion at the distal interphalangeal joint.

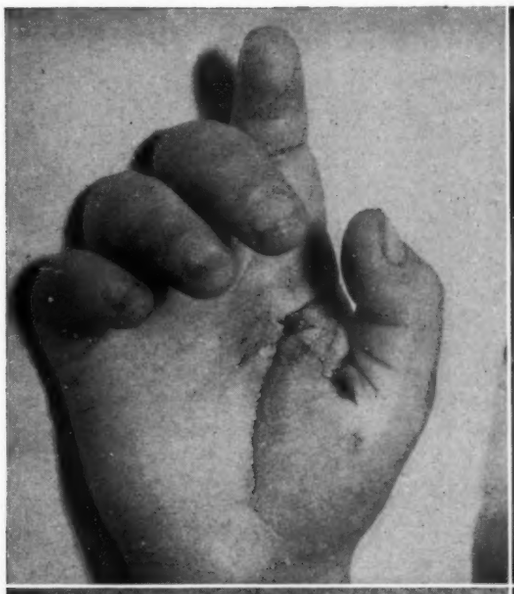
about the finger itself and the wound allowed to granulate and heal accordingly. These also result in good healing, except that the time for the healing process itself is rather long. When amputations themselves are necessary, the cartilage should be removed from the bone ends, and the nerves cut short and allowed to retract back into good, soft subcutaneous tissue. The flexor tendons are not sutured to the extensor tendons.

Tendon and Nerve Injuries. Tendon and nerve injuries occur rather frequently in injuries to the hand in children. Primary tenorrhaphy may be performed if done under proper conditions by interested operators. The flexor and extensor tendons in the wrist, palm and dorsal aspect of the hand usually do not give much difficulty. In the fingers, under ideal circumstances primary repair can be done. Fine suture material must be used and the tendon sheath must be left open. If the laceration is on the finger, the sublimis tendon is removed and the profundus alone is repaired. In the nerve, No. 6-0 silk is used and occasionally the nerves are so small that only one suture will be required. The splint is then applied in the position that will relax the tendons adequately and allowed to remain in place for three to four weeks. It is extremely important that the second dressing be done under ideal circumstances, for example under general anesthesia, so that the child does not struggle and tear the healing tendon or nerve into two parts. (Figs. 1 to 3.)

Secondary Tendon Procedures. It is often necessary to perform secondary tendon procedures on these individuals. Many times small cuts are deeper than realized originally. Most of our secondary procedures have been carried out where the original diagnosis of a lacerated tendon was not made. Tendon grafting can be done at any age. Allen[3] has had three patients under two years of age on whom tendon grafting procedures have been done and good results have been obtained. We have had two patients under two years of age on whom grafting has been done with definitely improved function.

In tendon grafting we usually use the exten-

2A



2B

3A

3B

FIG. 2. A, a six year old school boy had a lacerated palm with cut flexor tendons to his right index finger. Primary repair was done under general anesthesia (B).

FIG. 3. A, a fourteen month old girl suffered a severe laceration of the palm of her right hand with severance of the flexor tendons and digital nerves to the middle, ring and little fingers. In addition, the superficial volar arch was cut. Severe bleeding occurred and the child almost died from loss of blood. Primary repair was performed eighteen hours after injury and after adequate blood replacement had been carried out. Both the flexor digitorum profundus and the flexor digitorum sublimis tendons were repaired with No. 6o cotton suture material. The nerves were repaired with No. 6-o silk sutures. B, good flexor power noted after six months. There was no limitation of extension, and sensation was returning to the palm and proximal portion of the fingers.

4 5A 5B

FIG. 4. An eighteen month old boy suffered a lacerated flexor digitorum profundus and sublimis to his right ring finger when he fell on a milk bottle four months previously. Tendon-grafting procedures were carried out employing the extensor tendon of the third toe. At the end of nine months the child was able to bring the ring finger well into the palm and he has good function.

FIG. 5. Loss of flexion to the index finger resulted when this six year old boy suffered a cut at the base of his index finger. Tendon-grafting procedures were carried out one year after the original injury. A, extension possible following the tendon graft. B, flexion possible six months after the tendon-grafting procedures were performed.

sor tendons of the toes. The graft is placed so that it is extended from the distal phalanx of the finger to the proximal portion of the tendon in the palm. Care is taken to preserve the pulleys if at all possible. According to Allen, one does not have to worry if the tendon graft is too long or too short because the children accommodate themselves quite readily. It has been shown repeatedly that they grow as the child himself grows. (Figs. 4 and 5.)

Mangle and Wringer Injuries. Perhaps one of the most common injuries of all in children are wringer and mangle injuries. MacCollum, Allen and others have emphasized repeatedly the importance of these injuries with the severe results that may follow.

In wringer injuries the child, attracted by the moving parts of the wringer itself or in an endeavor to aid his overworked mother, will decide to help with the washing; and before it is realized the hand is severely caught in the wringer. If the hand and arm can be readily removed, only severe edema and perhaps hematoma formation occur. However, if the wringer itself becomes caught on the hand, forearm or the upper arm, severe necrosis of tissue occurs.

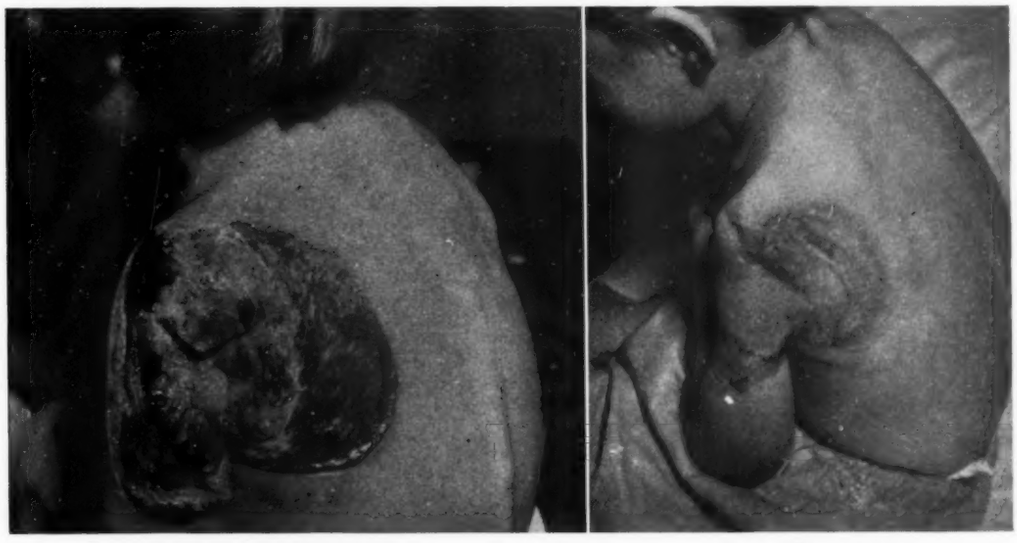
Although fractures themselves are quite rare, x-rays are taken routinely. Treatment consists of compression dressings. Hematomas, if present, should be aspirated, and laceration, if severe, should be sutured. (Figs. 6 and 7.)

More recently, with the increasing use of mangles in the home, one sees more and more mangle injuries. Here we have not only the friction of the rolling part itself but also severe burns result from the hot shoe of the ironer. Treatment is similar to that of wringer injuries although we are more inclined to admit routinely anyone with severe mangle injury for observation. Subsequent skin grafting, if necessary, is then performed. At the end of five or seven days the necrotic skin can be excised and a split-thickness skin graft applied to the hand itself. When subsequent contracture and healing occur, one can return, excise this and apply a free full-thickness skin graft. On the dorsal aspect of the hand, many times one can apply thick split-thickness skin graft that does not contract as much as on the palm of the hand itself. (Fig. 8.)

Burns of the Hand. Burns of the hand are frequently encountered with burns on the rest of the body. Usually the treatment is directed toward the burn as a whole. A compression type of dressing utilizing petroleum jelly appears to work best. The skin grafting should be carried out as soon as possible to control

6A 6B 6C

FIG. 6. A, severe wringer injury in a three year old boy, with destruction of all of the structures of the volar surface of the forearm. B, appearance of wound at first dressing change one week after the original injury. C, a large pedicle graft was applied at three weeks. This was detached at three weeks but reconstruction of the soft tissues of the forearm is still needed.



7A 7B

FIG. 7. A, two year old girl suffered a very severe wringer injury with damage to the brachial plexus and axillary artery. Destruction was so severe that exposure of the head of the humerus occurred. Hemorrhage developed from the axillary artery and ligation had to be performed. The head and shaft of the humerus were saved by utilizing a sliding pedicle graft from the anterior surface of the humerus. This resultant defect was covered with a split-thickness skin graft. B, six months later the humerus was viable. Motion and sensation has gradually returned to the forearm but a good deal of atrophy is present in the upper extremity.

infection; the hand is dressed in position of function and motion is started early. Later, if necessary, reconstructive surgery can be performed. Severe contractures often result from these burns since only a temporary skin dressing is applied and it is often necessary to perform secondary procedures. (Fig. 9.)

Skin-grafting. Skin-grafting procedures often have to be carried out following mangle and wringer injuries and burns. We attempt to cover the open areas as soon as possible with split-thickness grafts. Then, once the wound has been covered and infection controlled, further reconstructive work may be done. Occasionally it is necessary to apply a pedicle graft immediately to preserve bony structures, etc. Once healing has occurred, and if a contracture does result, this can be excised and free full-thickness grafts applied. We have found that by taking these grafts with the Brown Electric Dermatome almost a full-thickness graft can be obtained and this donor area does heal uneventfully. If the donor area does appear to be too deep, a split-thickness

8A 8B

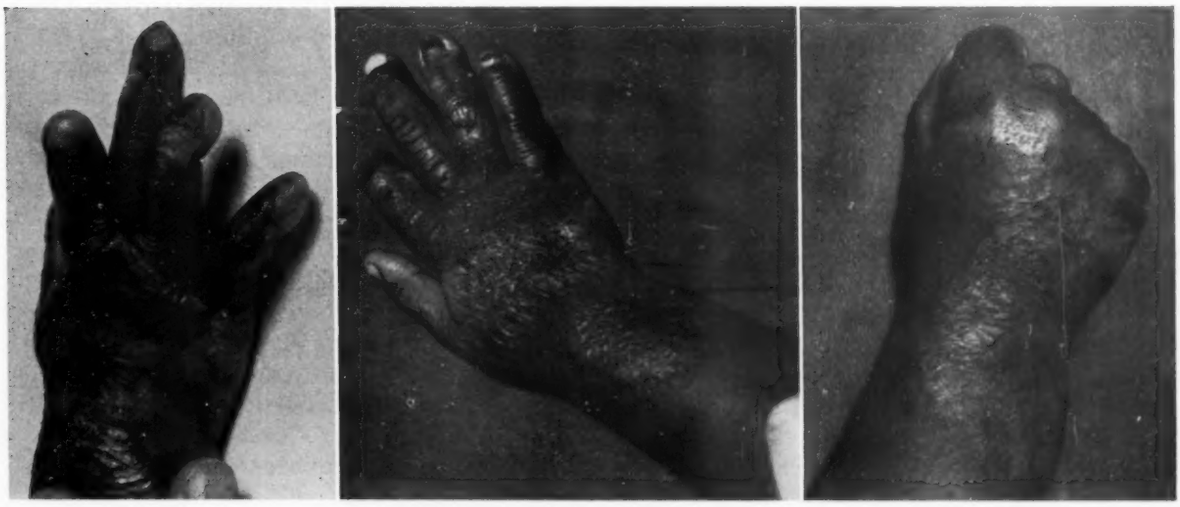
FIG. 8A and B. Severe mangle burns to the dorsal aspect of both hands in a two year old girl.

8C

FIG. 8C. Skin graft done on the fourteenth day. View of hands two weeks following skin grafting.

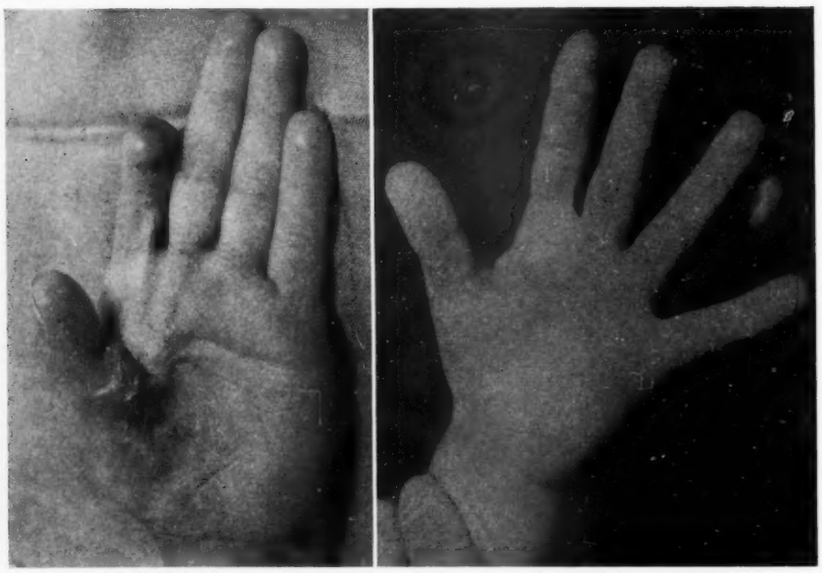
8D 8E

FIG. 8D and E. D, two years later extension showing skin graft well healed with only slight keloid formation. E, there is no limitation of flexion.



9A 9B 9C

FIG. 9. A, severe contracture following a severe burn on the dorsal aspect of the hand of a six month old child. B, scar excised and a free full-thickness skin graft applied. Extension three years later. C, good flexion is also possible with only slight limitation of motion being noted in the index finger.



10A 10B

FIG. 10. A, marked deformity in a hand of a four year old child following a wringer injury. B, after excision of the scar tissue and the application of a thick split-thickness skin graft obtained by the Brown Electric Dermatome, the contractures have been relieved to a considerable extent.

graft is taken immediately from a nearby area and used to cover the defect. The thick grafts do not have the tendency to contract that thin split-thickness grafts do and good results can be obtained. With the electric dermatome a good deal of time is saved. The graft is cut to pattern after it is obtained. (Fig. 10.) Care must be taken to make relaxing incisions at lines of stress; for example, at the flexion creases of the fingers small triangular darts should be made to prevent longitudinal contractures on the sides of the fingers. Occasionally a free full-thickness graft may be dissected from the lower abdomen or from the thigh and also used to cover the defect. Again, adequate immobilization is essential. Once the grafts have been sutured to the surrounding area with fine suture material, a moist cotton dressing is stented in place. The first dressing is usually changed one week after the operation. This is done under anesthesia; the sutures are removed and an adequate dressing is reapplied. It is extremely important to maintain these fingers on splints until adequate healing has occurred. We believe in maintaining them in the necessary position for three weeks, day and night; following this, splinting continues three months at night.

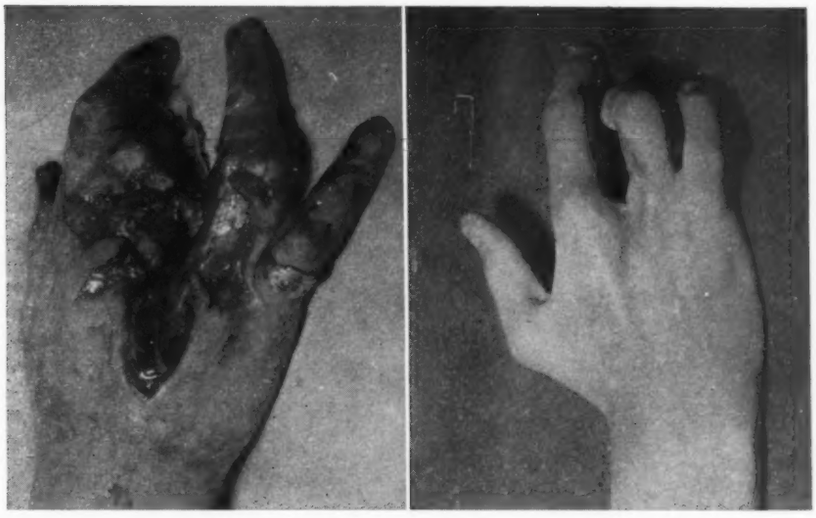
Fractures of the Hand. Actually one does not encounter too many severe fractures in injuries to the hand, but they can occur, of course, with occasionally severe deformities. The same principles are followed that apply to those in adults. The hand is dressed in position of function with traction wherever necessary. Occasionally, where an area has been missing, it may be necessary to do a bone graft. This, however, is quite rare.

Miscellaneous Injuries. In injuries to the hand in children, in addition to the more common types listed, one also encounters many other varied accidents. In this group four individuals suffered severe injuries from homemade rockets. (Fig. 11.) We not only have destruction of soft tissues, but also, open fractures with loss of digits are often encountered. Extensive reconstructive work consisting of tendon grafts and so on are often necessary.

In one case severe edema of the hand occurred when a rubber band was inadvertently slipped under a plaster cast on a three year old child. This cast had been applied for a fractured radius.

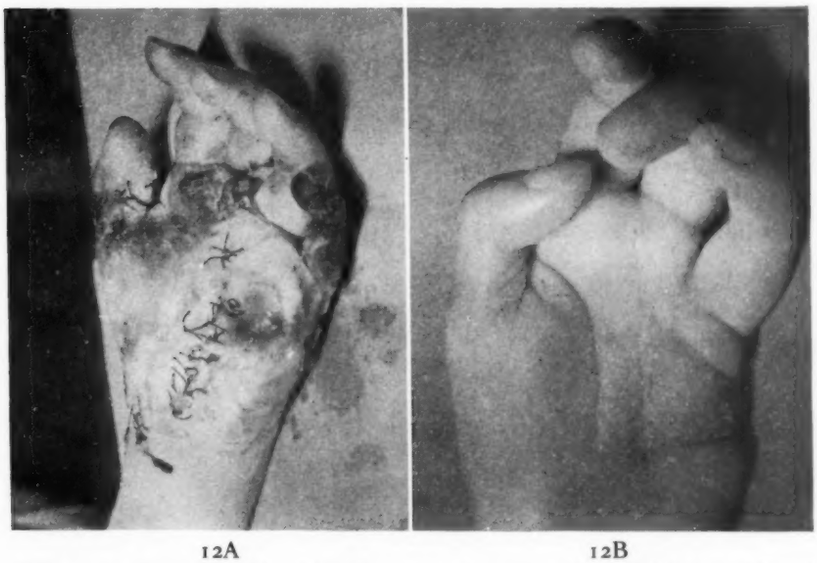
We had one farm accident and this was due to a corn shredder. In this case the patient needed a pedicle graft and bone graft. Tendon grafting must still be done. (Fig. 12.)

Other agents causing injuries are listed in Table II, and actually every type of conceivable injury appears to be possible in the child that



11A 11B

FIG. 11. A, severe explosive wound of the right hand of a fifteen year old boy who was experimenting with a home-made rocket. There is traumatic loss of the middle finger with loss of skin of the ring finger. B, six months following the original injury; the skin graft has taken well but scar contractures are present and there is definite limitation of motion due to joint injury.



12A 12B

FIG. 12. A, severe corn shredder injury in a five year old boy with loss of blood supply to the little finger and severe destruction of the fourth metacarpal. B, appearance one year later following the application of a pedicle graft and a bone graft to the fourth metacarpal.

is unprotected or, as noted in the older age group, is too inquisitive.

COMMENTS

Usually these children have no need to resort to any formal physiotherapy. They actually carry on their own therapy and are not inhibited by stiffened joints and other complications. They have no compensation worries. Usually, no matter how long the period of immobilization, joint stiffening does not occur. Good adequate motion, if at all possible, is obtained.

From a mental trauma point of view, the child himself appears to be less affected than the parent, especially if a severe wringer or mangle injury has occurred and the parent thinks that this is due to neglect on his part.

If at all possible, all reconstructive work should be completed before the child goes to school, for children ridicule cruelly.

I sincerely think that prevention of these childhood accidents is extremely important. Recently there have been several good articles published on just this problem. The large number of injuries encountered throughout the country has been mentioned heretofore. It has been stated that up to the age of twelve to eighteen months the infant needs complete protection from all accidents and hazards. If he is injured at that age, he has been denied that protection.[4] At the age of five or six his safety depends largely on what he has learned. If he gets into difficulty at that time, it has been stated that this depends on what his parents have taught him between the ages of one and five. Dietrich has pointed out time and time again that accident prevention requires forethought, time and discipline. "Discipline must serve when reason cannot." Explanations should be given, for example, if a child approaches a hot stove. He should be taught that "It is hot and will burn your fingers if you touch it."[4] Recently, in the Cleveland area, to prevent injuries in children a study has been made in which it has been estimated that 35,000 injuries occur each year in children under ten years of age. They have formed a speakers' bureau in which education of the medical profession and of parents is carried out.[5]

SUMMARY

A series of injuries of the hand in children have been presented. The surgical procedures necessary are shown in Table III.

TABLE III
SURGICAL PROCEDURES

Primary tenorrhaphy	34	Tendon graft	21
Primary neurorrhaphy	19	Pedicle graft	9
Fixation of fractures	25	Secondary tenorrhaphy	7
Amputations	13	Secondary neurorrhaphy	2
Lacerations	14	Bone graft	1
Skin graft	46	Tendolysis	1

Ages, sex, etiologic factors, types of injuries and treatment have been discussed. Prevention has been emphasized and follow-up care mentioned.

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Injury to the Achilles Tendon

EXPERIENCE AT THE MASSACHUSETTS GENERAL HOSPITAL, 1900–1954

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THERE are many reports in the literature of experience with individual cases of injury to the Achilles tendon. The nature of such publications, however, limits accurate appraisal of various technics of surgical repair. Two significant reviews are presently available in the Portuguese and French literature.[1,2] Tobin has recently published his experiences with delayed repair.[3] They serve as a baseline upon which to evaluate more recent methods of treatment. We have reviewed cases seen at the Massachusetts General Hospital from 1900 to 1954 in order to obtain a further understanding of the injury and the basic factors underlying definitive treatment. We believe that uniformity of good results in this series permits definite conclusions.

Adequate details for evaluation could be obtained in twenty-three of the thirty-one cases during this period. In the postoperative evaluation all patients were seen a minimum of one year following surgery.

Injury to the Achilles tendon comprised approximately one-fifth of all the large tendon injuries encountered. Five of the twenty-three patients have been classified as receiving delayed treatment as they were hospitalized from two to fourteen months following injury. During this period they had been treated for different diagnoses, most common of which was "sprained ankle." Their disability prevented full economic and functional activity; and although all patients were ambulatory, they had a marked limp due to the lack of "take-off" in walking. Of the eighteen patients seeking treatment initially, three were delayed by transportation up to ten days following injury.

With an average of forty years, the group ranged in age from seventeen to seventy-one years. There were four women and nineteen men. The injury was not bilateral in any of these cases, but recently one such case has come under our care.

A large variation in the tensile strength of Achilles tendons has been demonstrated by Cronkite.[4] In agreement with these observations is the variable degree in the magnitude of forces producing the injury. Of the eighteen cases in our series, the force could be arbitrarily classified as severe in five, moderate in ten and essentially incidental in three cases in which the trauma was indirect. There was no correlation with age and degree of force. In the four cases in which trauma to the tendon was direct, three ruptured following a moderate to heavy blow and one was due to laceration.

Eleven patients received their injury while engaged in athletics. The mechanism of injury in the eighteen patients whose trauma was indirectly transmitted to the tendon can be grouped into three main categories by history. Excluded are those three patients pursuing essentially normal activity at the time they "felt something let go" in their leg. Six patients described their foot as being passively dorsiflexed when it was caught in a fall. Five said their injury resulted when they pushed off on the foot, as when reaching for a hard shot in tennis. Four patients described jumping to the ground and landing with a taut tendon when they received their injury.

Symptoms and Signs. The predominant symptom was pain with all but five patients and there was only one who gave no history of pain. Weakness in plantar flexion was the most common associated symptom but was a subjective complaint in only one-half of the patients' histories.

On examination a palpable gap in the continuity of the tendon was present in all patients.

Pathologic Findings. The dehiscence of the tendon was complete in sixteen cases, with the plantaris muscle remaining intact in six of these complete ruptures. The separation occurred at the musculotendinous junction in eight cases, in the tendon itself in fourteen cases and at its insertion into the os calcis in one case. (Fig. 1.)

The findings at operation were usually those of hemorrhage and a markedly frayed tendon, the fasciculi being 1 to 2 inches in length, depending upon the location of the separation. When complete rupture occurred, the tendon ends were separated from 1½ to 2 inches. The

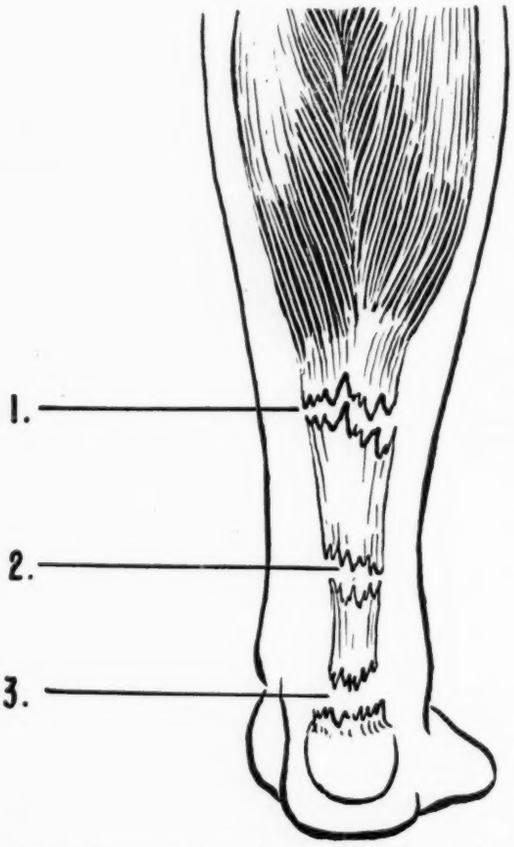

FIG. 1. Common sites of tear of Achilles tendon.

frayed tendon strands resembled a horse's mane, this characteristic presenting the chief technical difficulty in repair. No case undergoing delayed suture showed significant repair. Five biopsy specimens were submitted for study; four showed no abnormality and one section showed tenosynovitis in a case ruptured ten days before. These specimens were not prepared so as to show cholesterol foam cells. Therefore the presence of cholesterol cannot be excluded.

CASE REPORTS

H. S. (No. 143583, July 24, 1905), a twenty-three year old man sustained a complete laceration of the right Achilles tendon when cut by a piece of glass while bathing. This was repaired with silkworm gut and the patient was immobilized in a wire splint. One year later he ran well and was able to lift his weight on his foot but noted some awkwardness.

D. R. (No. 337145, April 25, 1914), a thirty-one year old shoe worker, slipped on a stair step, landing on his extended foot with pain in his right ankle. He could not forcibly flex his foot and there was a palpable gap in the Achilles tendon. At operation there was a complete rupture of the Achilles tendon in the upper portion. This was sutured with No. 0 chromic catgut. One year later he had resumed all previous activities.

A. B. (No. 263324, May 31, 1924), a twenty-nine year old peddler, two hours before admission felt something snap as he was jogging to first base in a baseball game. On examination there was a palpable gap in the tendon with severe tenderness. Complete rupture of the tendon at the musculotendinous junction was found at operation. It was repaired with No. 0 chromic catgut. Ten years later his result was classified as satisfactory, with complete functional recovery.

S. W. (No. 280724, December 13, 1940), a thirty year old lawyer, "pushed off" forcibly with his left foot while playing squash. He was unable to flex his foot without pain. When operated upon he had a completely ruptured tendon with an intact plantaris tendon. Repair was carried out with fascia lata and the plantaris tendon. Two years later he had no subjective complaints and was able to rise on tiptoe forcibly and painlessly, but 1 inch of calf atrophy persisted.

D. M. (No. 287616, February 5, 1941), a twenty-seven year old man, struck his right ankle with a racquet while stretching in a squash game. He felt something "give." On examination there was a palpable gap in the tendon, with pain on motion of the ankle. At operation a complete rupture at the musculotendinous junction was found. Biopsy of the tendon revealed no abnormality. The rupture was repaired with silk. His result was classified as excellent and the patient was able to walk on his toes with ease.

A. V. (No. 113629, August 23, 1943), a thirty-nine year old amusement park employee, jumped onto his left heel and experienced pain. On examination he had weak plantar flexion with a palpable gap in the Achilles tendon. At operation an incomplete tear at the musculotendinous junction was present. This was repaired with fascia lata and silk. Four months after operation he was able to walk 50 feet on the balls of his feet and had forcible dorsiflexion. He had no difficulty one year later.

A. M. (No. 453208, June 23, 1944), a fifty year old gas station attendant, stumbled and fell, with resultant pain in his leg and inability to flex his foot. On examination there was a palpable gap of 1 inch in his Achilles tendon. At operation there was a partially organized clot in the complete

rupture which was repaired with fascia lata. When finally evaluated three years later he was able to walk on his toes with ease but did have 1 inch atrophy of his calf.

H. M. (No. 533000, May 31, 1946), a thirty-eight year old man, injured his left heel playing volleyball four days prior to admission. He felt as though he had been struck on the heel while stretching. On examination there was diffuse ecchymotic swelling over the left ankle with a palpable tender gap in the Achilles tendon. At operation he had a complete rupture of the tendon. This was repaired with two 9 inch pieces of fascia. Three weeks later he was found to have separated the wound edges which had been brought together under tension. Some of the fascia sloughed. This complication was treated by incision débridement and secondary closure with the aid of a relaxing incision. When evaluated one year later he was able to stand on his toes, walk without pain and had no calf atrophy. (In this case one strip of fascia would have been sufficient.)

M. E. (No. 537751, July 5, 1946), a thirty-eight year old female dancing teacher, leaped while in a dance routine and experienced severe pain in the right calf following an audible snap. She had weakened painful plantar flexion. At operation an incomplete rupture of the tendon was found and repaired with fascia lata. Two years later there was ½ inch atrophy of the calf but she had good plantar flexion and no alteration in her dancing proficiency.

G. E. (No. 603732, January 6, 1948), a thirty-one year old man, fell over a stepladder, catching his heel, with resultant immediate pain in the left ankle. On examination he had marked tenderness and a palpable gap of 2 inches. At operation he had a complete rupture of the tendon at the musculotendinous junction which was repaired with fascia. Six weeks later on removal of his cast a hematoma was removed along with bits of fascia. One year later he had excellent function, no calf atrophy and good plantar flexion.

B. C. (No. 620813, June 5, 1948), a forty year old plastic surgeon, landed forcibly on his left foot as he jumped from his automobile. He had pain in the heel and a palpable gap in the tendon. At operation the complete rupture of the tendon was repaired with fascia lata. The final result, five years later, revealed excellent functional and economic recovery with ability to rise up on his toes without pain.

E. M. (No. 694039, March 7, 1950), a twenty year old female Austrian Olympic skier, fell forward when her ski tip was driven beneath the snow. She had a markedly tender concavity palpable in the Achilles tendon and inability to flex the sole of her foot. At operation a complete rupture was repaired with fascia and silk. She returned to Europe in a plaster cast after four days, and a letter received from her one year later stated that she had healed perfectly and was skiing as well as ever. She equaled her previous Olympic wins one year after injury.

E. G. (No. 150638, June 6, 1950), a sixty-one year old male shoeworker, four days before admission felt a sudden sharp pain in his right heel while working. He had severe pain and tenderness in the right calf muscle. At operation there was a partial tear of the musculotendinous junction, so that the medial head of the tendon was entirely free. This was sutured with interrupted silk sutures. One year later he was able to stand without pain on his forefoot. He did complain of easy fatigability of the leg.

G. S. (No. 82713, September 22, 1951), a seventy-one year old physician, stretched while playing deck tennis aboard an ocean liner. He experienced sudden severe pain in his left ankle and was unable to flex the sole of his foot. He had a palpable gap which proved to be a complete rupture of both the plantaris and Achilles tendons. This was repaired with fascia lata and a good final result was obtained with the patient able to stand on his toes and forcibly flex the sole of his foot.

A. V. (No. 214099, January 20, 1952), a twenty-four year old student, was injured when while playing basketball he was struck on the left heel by an opposing player. He had severe pain, weakened plantar flexion and a palpable gap in the tendon. At operation there was a complete rupture of the tendon with an intact plantaris muscle. The tendon was repaired with a wire "suture at a distance" held by a screw through the os calcis. A plaster boot was worn for four weeks. The wire and screw were removed in six weeks with novocain anesthesia. Six months later the patient could stand on the toes of the injured leg. He had normal motion of the ankle.

A. B. (No. 803701, March 4, 1954), a forty-eight year old woman entered the hospital with the complaint of pain and weakness in the right leg. Four hours prior to entry, while attempting to push off on her right foot for a forehand drive in tennis, she had a sudden onset of pain and giving way of the right lower extremity. Pain was localized to the posterior aspect of the right ankle joint. She was unable to walk afterward and was taken to the hospital where examination revealed moderate swelling of the right ankle and the lower leg with definite tenderness over the Achilles tendon and a palpable defect at the junction of the tendon and muscular portion of the Achilles tendon. Forced plantar flexion was impossible. Passive dorsiflexion produced pain. X-rays revealed no bone injury. The next day at operation the tendon was found completely ruptured at the junction with the muscle; the plantaris tendon was intact. Repair

was carried out with mattress sutures of fascia which was reinforced with silk. The wound was closed with cotton in the superficial fascia and with silk in the skin. A long leg cast was applied with the knee flexed 45 degrees. At the end of eleven days the long leg cast was replaced by a short one and this was worn for an additional thirty-six days. The patient was in a walking cast twenty-eight days after her operation. This was removed six weeks from the time of the operation. Since that time she has been walking about, wearing ordinary shoes and doing mild exercises to strengthen her calf muscle. At the end of four months the patient was walking on her toes without difficulty and had ½ inch atrophy of the calf. She had not yet returned to playing tennis but was driving a car and walking normally.

R. G. (No. 868006, August 20, 1954), a forty-eight year old college administrator, while playing volleyball felt something snap in his right leg; he fell to the ground, experiencing immediate pain in his ankle. Two days later he was admitted to the hospital where examination revealed a palpable gap in his tendon and he was unable to flex the sole of his foot. At operation a complete tear of the tendon was seen at the musculotendinous junction and a repair was carried out with fascia lata. He was kept in a long leg cast for four weeks and in a short leg walking cast for an additional two weeks. He walked with crutches for two weeks; eleven weeks after his operation he was walking normally and driving his car, and could walk on the balls of his feet without a limp.

E. C. (No. 867992, July 23, 1954), a forty-six year old businessman, sustained a rupture of his right Achilles tendon while skiing five months before coming under our care. The day following injury the ruptured tendon was repaired with silk at another hospital. All sutures were removed ten days after the operation. One month after operation a draining sinus developed at the mid-portion of his wound and this persisted for four months. Five months after operative repair of the tendon rupture the sinus was explored and several strands of silk were removed. The tendon was well healed and not involved in the infection. Following removal of the foreign body silk the sinus healed and has remained healed. The patient walks with a normal gait, performs his usual activities and can walk on tiptoe but has ¾ inch atrophy of his calf.

The following patients were seen several weeks or months after injury; suture of the injured Achilles tendons was delayed. The results in all were excellent.

J. B. (No. 13169, March 18, 1934), a sixty-one year old man, wrenched his right ankle while walking across railroad tracks two and a half months before admission. Although he experienced sudden pain, he was told by his family doctor that he had a sprained ankle and was treated with supportive bandages. When examined at this hospital, he had a definite defect in the tendon and weakened plantar flexion. At operation there was a complete rupture ½ inch above the tendon insertion, with an intact plantaris tendon. This gap was filled with partially organized fibrous tissue. The plantaris tendon and fascia lata were used for suture. He had an excellent result, with forcible plantar flexion and ability to stand on his toes.

J. F., (No. 33645, March 27, 1937), a forty-eight year old woman, felt sudden severe pain in her right ankle while surf bathing three months before entry. On physical examination she had a tender palpable gap in the tendon and weak plantar flexion. She had an incomplete rupture of the tendon at the musculotendinous junction which was repaired with silk and fascia lata. On evaluation plantar flexion was recorded as normal in strength.

T. K. (No. 159088, October 23, 1938), a sixty-three year old store manager, nine months before admission slipped on a stepladder, catching his foot, and fell 10 feet. There was resultant inability to flex his right foot and ankle. His pain persisted despite frequent strapping by his doctor. On examination he had ¾ inch calf atrophy, could not raise his heel from the floor and had a cord-like mass over the lateral part of his Achilles tendon. At operation there was complete rupture of the Achilles tendon at the musculotendinous junction, with the plantaris tendon intact. Fascia lata and plantaris tendon were used in repair. His result was classified as excellent, with forcible normal plantar flexion.

C. S. (No. 333707, January 21, 1942), a seventeen year old boy, was kicked in the ankle while "roughhousing" fourteen months prior to admission. The injury was treated by pressure and supportive bandage but there was continued pain. On examination he had a palpable gap in the lower Achilles tendon, with atrophy in the left calf and inability to walk on his toes. At operation there was complete avulsion of the tendon from the os calcis. Biopsy of the fatty material in the gap revealed no diagnostic abnormality. The tendon was sutured with silk. Fourteen days after operation an infected hematoma developed which responded to drainage and Dakin's soaks. On final evaluation he had no limp or pain and was able to lift the weight of his entire body on the toes of his left foot.

W. R. (No. 351375, September 27, 1947), a fifty-four year old caretaker, tripped and fell down a full flight of stairs two months before admission, with resultant pain in his right lower calf. When examined at this hospital he had weak plantar

flexion and a tender thickening in the Achilles tendon. At operation a complete rupture of the tendon was seen which was repaired with fascia and a stainless steel "suture at a distance." He returned to full activity in six months and was able to stand on his toes and walk without pain, but noted some awkwardness in the foot.

TREATMENT

Although an occasional case has been reported as being successfully treated with conservative measures, these patients undoubtedly had incomplete ruptures. All patients in this series were sutured following exposure of the tendon. With one exception all were immobilized for a period of three to four weeks in a toe-to-groin cast to hold the knee in flexion and the foot in slight equinus position; in the most recent case the leg was in a long cast for a period of eleven days. After a variable period of protected weight-bearing all patients were able to return to work or resume previous activity in three to five months. The technical method of suture was varied in our series, as listed in Table 1. The skin incision was uniformly made just lateral and parallel to the tendon. It does not matter whether the incision is medial or lateral to the tendon. However, an important consideration is not to place this incision directly over the tendon. In several instances the lower end of the incision was carried to the lateral aspect of the foot at a point above where the top of the shoe might rub against the scar. When suture of the tendon by silk or catgut was carried out, the ends were approximated by suturing the ends of individual bundles following débridement of the severely damaged tendon. Where fascia or tendon was used as the primary or supplementary suture, it was intersewn in the separated tendon fasciculi and into itself as well. (Fig. 2.) The plantaris tendon when used was always in conjunction with fascia lata suture, it being insufficient in amount when used alone. The principle of wire "suture at a distance," as advocated by McLaughlin[5] and Bunnell,[6] removes tension from the suture line by placing a wire suture in the proximal tendon which is then fixed to either a bolt through the os calcis[5] or a button on the tough skin of the heel.[7] This wire is later removed by a wire pull-out suture which has been brought out through the skin proximally. Approximation of the suture line by silk or reinforcement by fascia or tendon as advocated by Marble[7] completes this latter technic. The wire suture at a distance is removed in three weeks.

In three cases with simple fascial suture, separation of the skin suture line and resultant slough of some of the fascial suture and tendon resulted. It was the surgeon's opinion that in these cases too much fascia had been used in the repair and as a result there was ischemic necrosis due to tension with resulting skin suture line breakdown. Fortunately, none of these cases required resuture of the tendon and a good result was obtained in each following secondary skin closure by a plastic procedure. In a third case, in which silk suture alone was used, an infected hematoma developed and required evacuation. No further treatment was necessary.

TABLE 1
SURGICAL TECHNICS EMPLOYED FOR REPAIR OF TENDO ACHILLES RUPTURE

Type of Suture	Early	Delayed
Catgut	3	..
Silk	3	1
Silk and fascia	4	1
Fascia	6	..
Fascia with plantaris	1	2
Wire "at a distance"	1	..
Wire with fascia	..	1

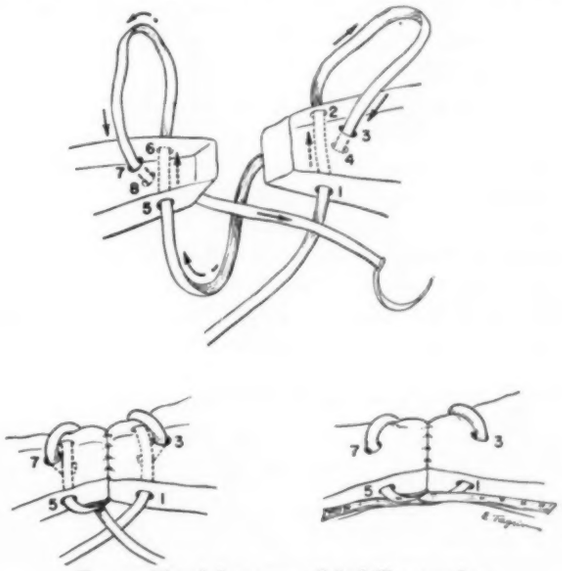

FIG. 2. Fascial suture of Achilles tendon.

The authors believe that the simplest and

most effective method of suture is by direct exposure of the lacerated tendon and the use of braided silk or fascia in the recent case, and of fascia in the patient with a laceration of more than three weeks' duration.

RESULTS OF TREATMENT

All twenty-three cases, regardless of the type of suture, can be classified as good results from the functional and economic viewpoint. Although one patient complained of fatigability and another two of awkwardness of the injured foot, all patients were able to stand on tiptoe on the injured side and to have forcible plantar flexion and dorsiflexion of the foot through a full range of motion. Measurable calf atrophy of ½ inch or more was a common end result observation. As evidence of the degree of functional achievement, one patient in this series was able to win 1952 Winter Olympic Games Alpine skiing events in spite of a complete rupture of the Achilles tendon repaired by fascial suture in 1951.

SUMMARY

Rupture of the Achilles tendon produces a persistent disability until treated by surgical repair. The diagnosis is frequently missed by the casual examiner. Twenty-five per cent of our patients sought treatment from two to fourteen months after injury. In our experience it is important to effect a satisfactory approximation of the tendon ends and to reinforce this suture line with fascia or tendon. An excess of fascia should be avoided in order to insure skin closure without tension. Regardless of the method of suture, if repair is carefully done and followed by four to six weeks of plaster immobilization, a good result can be expected.

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DISCUSSION OF PAPERS BY DRS. ROBINSON AND HARDIN, POSCH, AND LAWRENCE, CAVE AND O'CONNOR

Michael L. Mason (Chicago, Ill.): I would like to discuss the papers by Drs. Robinson and Hardin, and Dr. Posch. I do not like to engage in simple amenities and just say that both articles showed very beautiful results, which they did show. I think they have both emphasized the principles of primary care of these open wounds: first, that of cleansing the wound, then of excising tissue which is destined to become necrotic, and then of closing this wound, in the meantime carrying out what is possible in the way of reconstruction at the time of initial operation. Closure is accomplished by any possible means, as Dr. Robinson mentioned, either by skin grafts or by flaps.

When one has finished the excision of necrotic tissue or tissue which is bound to become necrotic, the surgeon looks at this hand and says, "This is what I have; what can I accomplish with it? What can I do with it? What sort of hand can I reconstruct?" That problem was certainly well illustrated in Dr. Robinson's cases.

In order to reconstruct a hand, one must have some sort of an idea as to what the function of the hand is. In these very severe injuries we often have to be contented with restoring only one function, that of grasp, or two functions, grasp and pinch. Many times we have to forego the finer actions of the hand because we do not have material to carry on that reconstruction.

We do not see many of the corn picker injuries although we do see a few, being in the corn belt also. The patients, usually are brought into Chicago for secondary reconstruction. Those we have seen have followed a rather definite pattern, which has been the amputation of the index, middle, ring and little fingers, frequently with the saving of the thumb and sometimes with a saving of a short stump of the little finger. That is the usual pattern of the corn picker injury which we have seen.

Dr. Posch has said, and we feel very strongly, too, that the same principles apply to the care of wounds in little children as apply to the care of wounds in the adult. They are very nice patients to take care of, because with careful, gentle work and adequate care one should get good results. The tendons and nerves heal nicely and children do not require a great deal of physical therapy afterward to get hands back into use.

As for secondary repair, we are often confronted with a little child with a divided tendon which has not been repaired. The comment is

made, "You cannot do that in a baby. You cannot repair a tendon in an eighteen month old child or a three month old child. The tendon will not grow. You employ a tendon graft and it will stay the same size, or you use a large skin graft and it will not grow." This, of course, is not the case.

It is very interesting to follow up these children over a period of many years and to find that skin graft, which when applied may have been a tiny graft over the back of the hand, has spread out to the normal size of the hand. The same thing applies likewise to a tendon graft, which will also grow.

We have seen children in whom a tendon had divided a year or two previously with retarded growth of the finger. If we put in a tendon, that finger and the tendon itself begin to grow and develop.

The difficulty in diagnosis in children concerns mainly the attempt to discover whether or not a nerve has been divided. In the two or three year old child one cannot get response as to nerve division, and it is sometimes difficult to get a response as to tendon division.

Even after repair we have seen children refuse to use their fingers for two or three months after an absolutely satisfactory tendon repair and all of a sudden start to use them.

Dr. Posch has cited some work in which the parents are supposed to be held responsible for all their children's injuries. I think the child has a little responsibility on his own account. We all have to learn, I think, by personal experience that a hot stove is hot and burns, and hurts.

Thomas B. Quigley (Boston, Mass.): I would like to congratulate Drs. Lawrence, Cave and O'Connor on their excellent review. In eight years at the Peter Bent Brigham Hospital we have had ten ruptures of the Achilles tendon. Since these have all been taken care of by one surgeon using the same technic, they might be worth presenting very briefly.

Most of these occurred in self-styled athletes in their middle years, a few in young men. The diagnosis, as has been pointed out, remains a little mysterious at times to the general practitioner because several were referred for rupture of the plantaris tendon or severe and mysterious sprains.

The reason for the confusion in diagnosis was that the sole of foot could be flexed. It was forgotten that a good many things will flex the soles of the foot besides the gastrocnemius.

We always make a medial flap-type incision to avoid any possible injury to the sural nerve. We use a pull-out wire more as a safety measure than anything else. The plantaris tendon has been used as living suture when present, which is in about three-quarters of the cases, leaving it attached to the heel, threading it back and forth across the point of rupture. Fascia has also been used at times. In one old case it was absolutely necessary to use fascia.

Dr. O'Connor's beautiful picture of the use of fascia, showing the crisp ends of the tendon, intrigues me, because at the other side of Boston the ends of the tendon are not quite that clean-cut. It is sort of like sewing two paint brushes together end-to-end, and to get the suture material in requires a bit of doing.

We do not put holes in the os calcis, as McLaughlin has recommended, believing that if the os calcis is involved in complications they are likely to be serious and prolonged.

The cause of rupture has interested everyone. We have biopsied most of these and have confirmed the pathologic findings reported by McLaughlin to this society a few years ago. Those findings, in general, are local chronic ischemia or avascularity.

Recently Dr. Edward Edwards, a surgeon who is also a gross anatomist of distinction, has been reviewing the blood supply of muscles of the extremities. One would not think that the much harvested field of gross anatomy could provide any more gleanings, but it has been so in Dr. Edwards' hands. He has shown by injection studies in cadavers that the point of least blood supply to the tendo achillis is at the point of junction of the tendon and the muscle belly. A certain amount of blood comes from the distal tendon and most of it comes from the upper belly of the muscle. This might well have a bearing on why these injuries occur.

Howard E. Snyder (Winfield, Kan.): I should like to discuss these three fine papers, first to emphasize Dr. Robinson's point that we should participate in the safety programs and educational campaigns which are in progress. I should also like to point out that the farmer has to deal with more machinery perhaps than any other individual, certainly more than even an orthopedic surgeon. He has his tractors, combines, corn pickers, chain saws, all sorts of equipment which he must learn not only to use, but also to service and to keep in repair.

I should like to call your attention to the fact that a great deal has been done in the way of safety programs through the Department of Agriculture and the various farm bureaus, the 4-H Clubs, the Future Farmers of America, the National Safety Council, and certainly very prominently among these, the implement companies who have provided motion pictures and pamphlets to educate the farmer along the lines of safety.

I think perhaps we have more of a problem in educating the parents of children, which was brought out by the authors of the second paper. I do not believe that we are conducting as much of

a safety campaign in homes and among our general civilian population as has been conducted among the farm groups. The accident and mortality rates from farm injuries in Kansas have been reduced remarkably in the last twenty years because of these campaigns.

DAVID W. ROBINSON (closing): I wish to thank Drs. Mason and Snyder for commenting upon our paper. Only one further point for re-emphasis: I wish someone could help us find a way to tell what tissue is dead and what is going to die within the next few days. It is very embarrassing when dead tissue is covered up and has to be removed later. (I have done it and I am sure others have).

In the accidents and injuries which we discussed necrosis is very often late. This is probably due to arterial injury; later on one sees a definite demarcation and then the part can be removed. I think it is better if one would be a bit conservative at this time and leave as much length as possible. As we said previously, it is easier to remove, so much harder to save and ten times harder yet to try to substitute for the damage that has been done.

In these cases, when opening up the palm a bit (not opening it up any more than is necessary to do the débridement mentioned by Dr. Mason), we have seen the arteries in marked spasm; and even though they are not torn, almost no blood is going through them. In spite of sympathetic blocks and sympathetic blocking agents, we have had no success in opening up these arteries which have, by their spasm, produced gangrene at a later date. I therefore re-emphasize the point of conserving tissue, saving as much as possible, and not being in too much of a hurry to remove things in the very beginning.

JOSEPH L. POSCH (closing): I wish to thank the discussers for their presentations and to emphasize one point. When dressings are changed at the end of a week or ten days, it is usually done in the operating room under anesthesia so that the patient will not struggle and fight, thus breaking any tendon repair that has been done.

Repair of Skull Defects

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THIS presentation is concerned with the present status of cranioplasty, the precautions that should be followed and the pitfalls that should be avoided in the repair of skull defects. No attempt will be made to review the history of cranioplasty or to discuss the indications and contraindications. The reader is referred to the article by Grant and Norcross in 1939, the review by Woolf and Walker in 1945 and the monograph by Reeves in 1950.

At the present time the use of alloplastic materials is popular and their advantages, at least in many circumstances, are obvious. However, some surgeons still prefer the use of autogenous bone grafts and these have not only a sentimental value to some patients but have the sterling value of not causing tissue irritation or foreign body reaction. Never in my experience has it been necessary to remove or replace an autogenous graft because of infection or evidence of tissue reaction. Their disadvantages include the additional operative procedure required to obtain them, the difficulty in reproducing the original contours of the skull, and in the case of periosteal outer-table grafts the lack of stability in grafts of large size. (Figs. 1 and 2.)

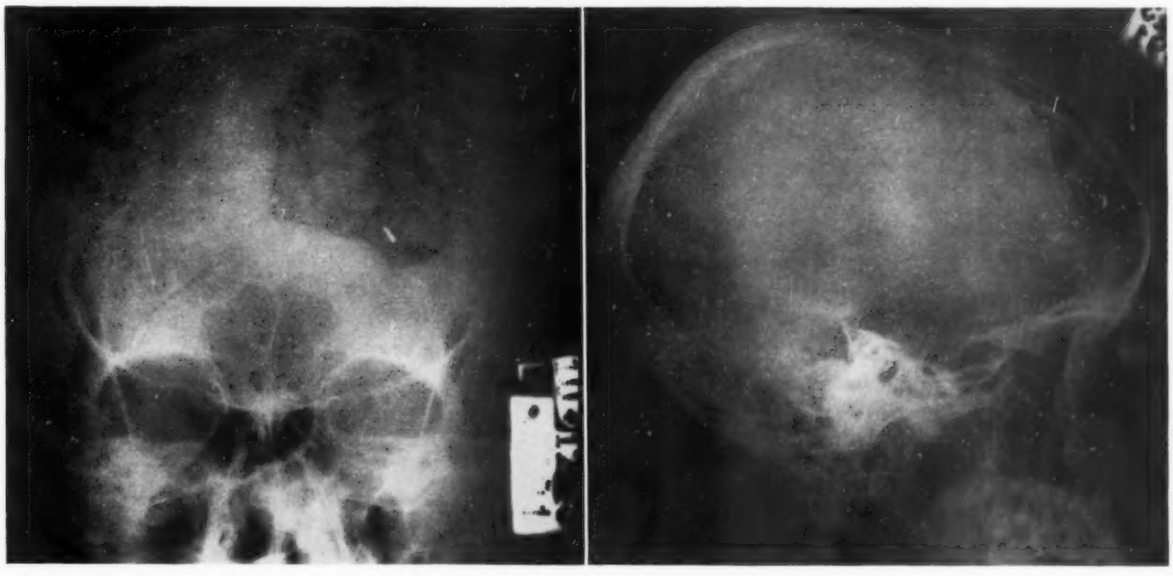

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FIG. 1. Frontal skull defect repaired with periosteal outer table graft. Anteroposterior view.

FIG. 2. Same case as Figure 1. Lateral view. Note lack of rigidity of the graft.

The use of preserved grafts, usually boiled bone removed at the time of operation has been frequently reported. This method is especially applicable when tumor, usually meningioma is found to invade a bone flap. Such a flap can be removed, boiled to kill the invading tumor cells and replaced. Accidental contamination of a so-called free bone flap or trephine button intended to be replaced can be managed in the same way.

As might be expected the literature lacks reference to such cases with the exception of an occasional passing reference in surgical protocols. When this method is used as a

3 4

FIG. 3. Tantalum cranioplasty for postoperative parietal skull defect. Anteroposterior view.

FIG. 4. Same case as Figure 3. Lateral view.

primary procedure, it has proven satisfactory in the majority of cases. When the replacement of boiled bone has been a delayed procedure, carried out at a second operation, my experience is similar to that of Ray and Parsons. In such cases the incidence of infection and enforced consequent removal has been high. As Gurdjian stated these boiled grafts tend to absorb. This is not serious as they are replaced by plates of firm fibrous tissue which are quite satisfactory from a cosmetic and protective standpoint. With the development of bone banks the use of homogenous grafts of preserved bone has become feasible (Odom, Woodhall and Wrenn). It is likely that such grafts will usually absorb but as was just pointed out, while this is a theoretic disadvantage, actually it is not a serious one. Abbott has reported on the success of such grafts.

The technic of using alloplastic materials will be discussed under two headings; the first preforming the plate by casting or swagging the material under pressure to fit a cast or moulage of the defect and, second, molding or fitting the plate at the time of operation. The first method is necessary when alloys like vitallium® or plastics like methyl methacrylate are used since these cannot be molded or altered at the operating table. Some surgeons have preferred to use preformed tantalum® plates although the latter metal is malleable and can be trimmed and shaped satisfactorily at the time of operation. In order to obtain a really satisfactory cast or moulage of the defect a two-stage procedure with preliminary exposure of the defect and taking of an impression is necessary. True some surgeons have kept the patient on the operating table while the whole procedure was carried out; but even when an abundance of technical help made that feasible, the operations were unduly prolonged.

One of the great advantages of an alloplastic graft is its availability. In order to take full advantage of that availability it should be possible to sterilize the material quickly and rapidly form and fit the plate at the operating table. In addition the material should be sufficiently rigid to give satisfactory protection and a good cosmetic result. A non-radio-opaque substance is desirable so as not to interfere with later roentgenograms of the skull.

Tantalum has been popular for the repair of skull defects since it can be kept available at all times, can be quickly sterilized and has satisfactory rigidity. (Figs. 3 and 4.) Fitting the plate to the defect and fashioning a proper contour is somewhat time-consuming, and requires at least a rudimetary knowledge of working metal by hand. A ball-peen type of hammer and curved wooden forms are helpful. These can be kept at hand and readily sterilized with the plate. Tantalum is radio-opaque

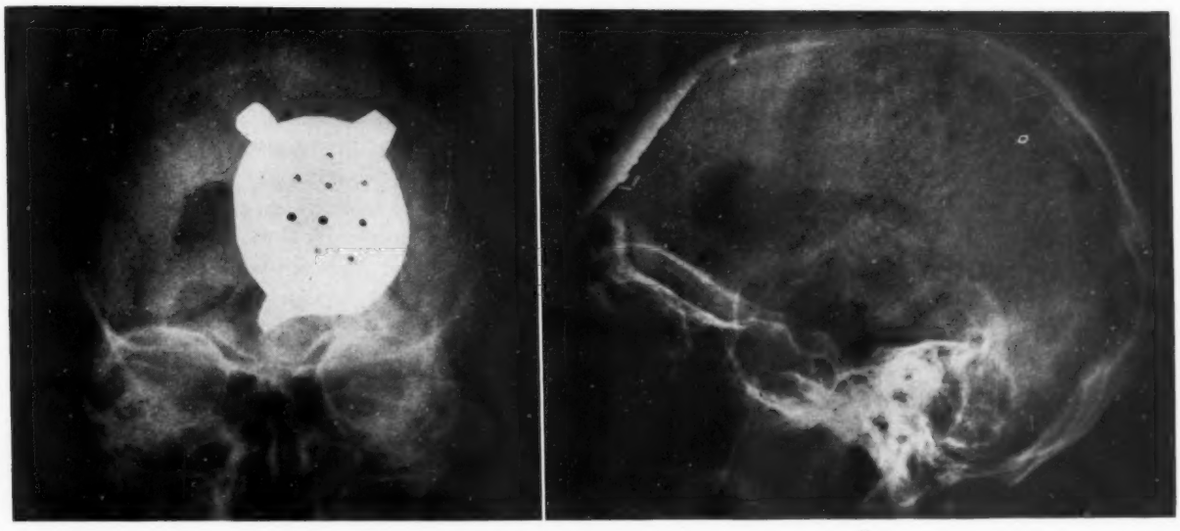

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FIG. 5. Tantalum cranioplasty for postoperative frontal skull defect. Note interference of the radiopaque plate with visualization of the ventricles by spinal air injection. Anteroposterior view.

FIG. 6. Same case as Figure 5. Lateral view.

FIG. 7. Polythene cranioplasty. Photograph at operation of the fashioned plate fitted and wired into the skull defect. Black and white reproduction from original color transparency.

and large plates greatly interfere with subsequent radiographic examination of the skull. (Figs. 5 and 6.)

Polyethylene plates appeared to Alexander and Dillard to be a satisfactory answer to some of the objections to tantalum. The material can be shaped more rapidly as after immersion into hot water the plate can readily be shaped to the proper contour. The shape is then retained by plunging the soft but properly shaped plate into cold water (0°C.). These plates lack the rigidity of tantalum but do seem to give satisfactory protection. (Fig. 7.) (Lockhart et al. compared tantalum and polythene in a series of twenty-four patients, each material being used in twelve patients. They found them equally well tolerated but noted that patients with polythene plates tolerated exposure to hot sun better than those with tantalum plates.) Polythene plates are non-radio-opaque

and do not interfere with later radiographic examination of the skull. I have had more difficulty with their retention in a series of twenty patients; three have had to have their plates removed because of persistent accumulation of fluid between the scalp and the plate. This complication has never occurred with tantalum. In fifty-two patients who have had skull defects repaired with a tantalum plate, only four have had to have the plate removed later. In none of these was there persistent fluid accumulation. Sterilization is more of a problem with the polythene plate. Unless a supply is kept sterile, twenty-four to thirty-six hours of immersion in the sterilizing solution are necessary.

Spence has recently devised a method of using a quick-setting plastic (a highly refined methyl methacrylate resin) and rapidly casting a plate to fit the exposed defect. Kits with this material assembled are available. The plates appear more strong and rigid than polythene plates since they are cast to the full thickness of the skull. My experience with this method is still too limited to warrant any conclusions about the risks of chronic infection and tissue reaction which are my present principal objections to polythene plates.

It might be stated again at this point for re-emphasis that if the surgeon and patient are willing to put up with the additional operative procedures necessary to obtain autogenous grafts, the sometimes crude cosmetic results and the lack of rigidity in some large grafts of this type, they will have no reason to worry about loss of the grafts from chronic infection or persistent tissue reaction. However, if alloplastic materials are to be used, certain principles should be followed and certain precautions observed.

Alloplastic materials should never be placed in a contaminated or chronically infected wound. Both traumatic and operative wounds must be solidly healed for at least three and preferably six months. The use of intensive chemotherapy and antibiotics may at times enable one to violate this principle successfully but in most cases failure will follow such violation.

The scalp overlying an alloplastic plate must be viable with an adequate blood supply and closure of the scalp must be accomplished without tension. Alloplastic plates cannot be used beneath a scalp that does not have an adequate blood supply from the base of the flap (or flaps) since the plate will prevent the scalp from acquiring any blood supply from the tissues beneath it. In certain large defects of some standing the overlying scalp has shrunk because of its collapse over the defect. This is especially apt to happen if there has been previous chronic infection of the scalp as in osteomyelitis of the skull or if high voltage roentgen therapy has been administered as in cases of brain tumor. In such cases if the normal contour of the skull is restored by accurate molding or preforming of an alloplastic plate it will not be possible to stretch the previously contracted scalp flap over the plate without undue tension on the wound. In two patients with large defects due to removal of osteomyelitis of the skull, a large tantalum plate and a large preformed plate of methyl methacrylate had to be removed because of persistent drainage and exposure of the plate due to wound separation. This had followed suturing under undue tension of a contracted scalp which we attempted to stretch over a large plate which had been molded to restore the previous contour of the skull.

In such cases satisfactory cosmetic results must be foregone and the defect repaired with a flat plate. Better still, alloplastic materials should not be used. A multiple-stage repair using rib cartilage or bone and gradually building up the defect with two or more separate procedures is more apt to be successful.

Accumulation of fluid between the scalp and the plate seldom occur with autogenous grafts and in my experience only when such grafts have been of boiled bone. It usually occurs with alloplastic plates and occasionally has been persistent with polythene plates. Three polythene plates in my series had to be removed because of the persistent accumulation of fluid between the plate and the scalp. However, two of these had been placed over porencephalic cysts which were in communication with a ventricle and were not covered by dura. (Tantalum has been tolerated by these patients after its substitution for the polythene plate so that the experience with these two patients indicates that polythene should not be used for repair of a skull defect unless there is an intact dura.)

It has been my experience that alloplastic plates should have several perforations no matter what material is used. Perforated

plates give less trouble with fluid accumulation. Adhesions between scalp and dura form at the site of the perforations and further fix the plate. It has not been necessary to remove perforated plates because of persistent fluid accumulation between scalp and plate except in the two instances of polythene plates over a porencephalic cyst without intact dura beneath the plate. The other polythene plate that had to be removed had not been perforated.

When fluid does accumulate between the scalp and the plate, it should be removed by aspiration, using sterile precautions. The removal of this fluid is especially important during the first few days after operation. Undue tension of the suture line should not be allowed to develop lest spontaneous drainage begins. If this occurs, drainage usually persists with a chronic fistula and eventual removal of the plate is necessary. The frequency of aspirations and the duration of the need for them varies from case to case. If the recurrent accumulation of fluid persists more than a few days, the aspirations can be spaced progressively further apart after satisfactory wound healing has occurred.

Autogenous grafts using ribs, rib cartilage or periosteal outer-table grafts have been carried out in thirty-one patients. No failures of these grafts have occurred for technical reasons. One woman had a supraorbital defect due to multiple operations on a homolateral frontal sinus. This was the site of persistent discomfort. It was repaired with rib cartilage. The repair was technically satisfactory and the cosmetic result excellent. The graft was removed eighteen months later at the patient's insistence because of the persistence of her discomfort. Her subjective symptoms continued after removal of the graft.

In twelve patients autogenous boiled bone grafts were used. In one patient the graft was preserved in formalin for three months before replacement. This graft had to be removed four months later because of chronic infection and continuous drainage from the wound.

Alloplastic plates were used for the repair of skull defects in eighty-five patients. Tantalum was used fifty-two times, polythene twenty times, preformed methyl methacrylate four times, Spence's rapid setting highly refined methyl methacrylate four times and vitallium five times. Eight (9.4 per cent) of these plates have been removed. Four of these were tantalum, three were of polythene and one preformed methyl methacrylate. As previously stated, the three failures with polythene were due to persistent (two months or longer) accumulation of fluid between scalp and plate in spite of repeated aspirations. The preformed methyl methacrylate and one of the tantalum plates were very large (six inches in the longest diameter) and a previously contracted scalp was sutured under undue tension. Wound separation, exposure of a portion of the plate and persistent wound drainage made the removal of these two plates necessary. Two tantalum plates were tolerated, one for six and the other for eight months. Then draining sinuses in the operative scar developed and eventual removal of the plates was necessary. Another patient tolerated the presence of a moderately sized plate in the frontal region for seven years. Then the overlying scalp was contused by injury during a convulsive seizure, a draining sinus developed and the plate had to be removed.

SUMMARY

Autogenous grafts of ribs, rib cartilage, iliac bone or periosteum and outer-table of the skull are better tolerated than anything else in the repair of skull defects. Boiled bone is usually tolerated well if used at a primary procedure. Frozen bone (bank bone) may be as satisfactory as fresh autogenous bone but more experience is necessary before any final conclusions regarding this can be drawn.

Alloplastic grafts have the advantage of availability, strength, good cosmetic results and less extensive surgical procedures. Failures are due to breaking down of wounds, recurrent chronic infection, persistent fluid accumulation or late trauma to the overlying scalp. Greater care and special precautions are necessary for the successful use of alloplastic materials for cranioplasty.

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Response of the Pial Circulation to Fatty Emboli Studied by Cinemicrophotography

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In the course of cinemicrophotographic studies of the cerebral circulation during the past several years, the response of the circulation to emboli has been recorded. By this method of study it is possible to understand better the clinical and pathologic results of fat emboli which may accompany injuries, particularly fractures. Since fat emboli frequently involve the cerebral blood vessels and sometimes with a fatal issue, the general surgeon and the neurologist or neurosurgeon have this problem as a common interest. Before discussing the experimental findings in the Rhesus monkey, certain aspects of fat embolism will be considered in the next few paragraphs.

CLINICAL ASPECTS

The incidence of fatty emboli has been reported mainly in conjunction with extremity fractures. Warren[29] has reviewed one hundred cases in young males and found that in ninety-one fatty emboli followed fractures, of which eighty-two were of the femur, tibia or both. Cerebral manifestations occur in about 25 per cent of the cases. Statistics[26] indicate that death occurs in from 20 per cent to 5 per cent[32] of cases. Minor and asymptomatic fatty emboli occur commonly in long bone fractures. A free interval or symptomless period is a clinical characteristic of this condition. The period is usually three to six days.

A cardiorespiratory syndrome may accompany the fat emboli with cough, fever, chest discomfort, dyspnea, fall in blood pressure, cyanosis and pulmonary edema. Petechial hemorrhages may appear on the skin, involving usually the chest, extremities and the conjunctional sacs. The number of the hemorrhages does not bear upon the prognosis. Fat droplets may be present in the sputum[30] but usually not for about thirty-six hours after the onset.[20] Recently it has been shown that fat is found normally in the lungs in both fasting and lipemic animals[31] and in the sputum of humans with diseases other than fatty emboli.[15]

The urine may contain fat two to six days after the injury.[21] Occasionally the fundi may reveal hemorrhages and exudates.[25,28]

Cerebrovascular syndromes occur in this condition with symptoms and signs which range from headache and disorientation to coma and death. Since head injuries frequently accompany a long bone fracture when cerebrovascular symptoms and signs appear, the possibility of an extravasation of blood within the skull becomes a clinical possibility. An increasing loss of consciousness, convulsions and focal signs may further support the diagnosis of a subdural or epidural hematoma. The desperate circumstances of some of these cases make it imperative to reach an accurate diagnosis. Careful judgment demands evacuation of the extravasation and conservative treatment for the non-surgical, petechial lesions.

PATHOPHYSIOLOGIC ASPECTS

Fat emboli may have their origin from the marrow of bones and the subcutaneous fat. The fat in a fluid state enters the circulation through a torn vein to be distributed to the pulmonary capillaries. Some emboli reach the left side of the heart to enter the arterial circulation.

The liquefied marrow is said to be an important source of the fat, the marrow cavity being in communication with the venous circulation. Vance[26] has found from 4 to 6 cc. of fat at fracture sites. The quantities of the fat and the particle size are main factors responsible for effects. Large quantities are needed to produce death in dogs, about 2 cc. intravenous per kg. In man a comparable volume would be 150 cc.[29] Wilson and Salisbury[32] found that globules of fat up to 12 microns in diameter will pass the pulmonary capillaries.

Prinzmetal et al.[17] have reported that glass spheres much larger than the diameter of the lung capillaries pass through the pulmonary

vessels in the dog and rabbit. Tobin and Zariquiey[24] found arteriovenous shunts in isolated human lungs many times the accepted diameter of capillaries. Shunts were demonstrated to permit the passage of glass spheres up to 500 micra. Spheres larger than 500 micra were held up in the arteries.

Since capillaries of the brain are 8 microns and arterioles 20 microns, capillary and precapillary obstruction would seem most likely. When fat exists as tiny particles (chylomicrons), it is said to be innocuous, normal blood containing .6 to .7 per cent of lipid increasing in pathologic states as in diabetic coma to 20 per cent.

Attention has recently been given to the possibility that fat emboli may result from derangement in the chylomicrons and their relationship with the red blood cells. The red blood cells of dogs and humans observed in whole blood smears by dark field illumination "had a tendency to aggregate, be adhesive to one another, and to become distorted 4 to 9 hours after a large fat meal."[23]

When vessels of the cheek pouch of the hampster were studied by cinemicrophotography, similar phenomena were observed. Four to seven hours after a fat meal "when the chylomicron count began to fall," the red cells became adhesive, rouleau formation increased, the speed of the circulation decreased, aggregations developed of red cells in clusters of 4 to 12 or more cells and these developed an "amorphous" appearance, the outline of the cells being lost.[23]

Davis and Musselman[5] have suggested that fat emboli which occur in burns, shock, poisoning, anesthesia, etc., as well as in fractures may be the result of a state of stress with an increased concentration of lipids and lipase which results in destabilizing the formed elements in the blood. Capillary plugging then may occur.

The end result in a fatal patient is a typical pathologic picture. The brain grossly upon cross sections presents, besides edema, tiny punctate hemorrhages more prominent in the white than in the grey matter. The petechiae, microscopically, represent thrombosed arterioles or capillaries with "rings" of necrosis and red blood cells.[23]

METHOD

Experiments were performed upon Rhesus monkeys under pentothal anesthesia. Acute and chronic experiments were made. A glass port or window was performed and placed into the monkey's skull in the parietal area prior to photography. The part was form-fitting, water cooled, water tight and adjustable in relation to the brain surface. Lighting the brain surface was by means of carbon arcs with cooled reflecting beams. The microphotography was accomplished by means of a lens system, beam splitter and motor driven Cinekodak. Observation of the blood pressure, respiration and other pertinent measurements were recorded with a Sanborn recorder. Emboli of fat and particulate matter were introduced into both the arterial and venous systems.

RESULTS

1. Under the condition of these experiments (using the Rhesus monkey and pentothal anesthesia), there was recorded a slight expansion of the pial arteries as the fat emboli initially slowed the circulation (2 cc. pantopaque into the carotid artery). A generalized vasoconstriction was not observed.[27]

2. Fat emboli of various particle size were recorded within the large veins in a brief shower seconds after reaching the arterioles and capillaries.

3. Arteries and veins were found to expand locally as globular and elongated fat particles coursed through the vessels. The vessels expanded segmentally when obstructed by an embolus as the column of blood forced the embolus onward.

4. Both localized and segmental defects in the arteries were found to be due to irregularities in the dynamics of flow and not to changes in the size of the vessel.

5. Emboli lodged at bifurcations with surrounding turbulence of cell free plasma. This simulates a point of localized constriction. The unconstricted artery wall, however, may be brought into focus to reveal its unvarying caliber.

6. An area of cell free plasma or an unstained embolus may suggest a "localized constriction in a vessel" or an "incisura."[27]

7. A thinning of the arterial flow through an artery may suggest a segmental constriction. This also results in no change in the size of the vessel's lumen.

8. Illumination of an artery or vein may result in aberrations suggesting changes in caliber which are artifacts.

9. Reversals of blood flow in arteries and veins of all sizes were commonly found as the pial circulation attempts to utilize patent vessels. Unpredictable courses were taken by emboli as a result of disturbance in flow.

10. Arterial shunts are common. Arteriovenous shunts have not yet been recorded.

11. The remarkable anastomoses of the pial circulation results in emboli being swept into the deep circulation resulting in the obstruction of the vessels in the white rather than the grey matter.

12. The vasostability of the pial circulation was constantly found in the absence of vasoconstriction either generalized or segmented. Expansion of vessels was of a mechanical nature.

13. Study of the pial circulation up to six days after the introduction of fat emboli into the carotid artery, sufficient to produce acute neurologic effects, failed to show prolonged autonomic effects. The cortical vessels were of normal appearance.

COMMENT

The importance of information regarding the cerebral circulation in terms of total flow and the activity of all caliber vessels is of clinical rather than theoretic importance.

The newer concepts of accurately diagnosing and treating patients with cerebrovascular diseases who represent an enormous and ever growing group of sick people depends upon this kind of information. The effect of diagnostic contrast media used in angiography, the effects of therapeutic drugs called cerebral vasodilators and constrictors, the use of surgical measures of carotid ligation, hypotensive anesthesia, sympathectomy, etc., are related to accurate knowledge of the dynamics of this part of the circulation of the body. Cinemicrophotography would seem to be a useful instrument in study if it can be perfected.

Investigation involving the circulation of the brain dates back many years and these investigations have employed many different methods. An early method used in 1858 by Claude Bernard[2] was the measurement of the temperature of the brain on the side of an extirpation of the superior sympathetic ganglion. Other methods have included, first, direct observation of the pial vessels as far back as 1830 by Brachet.[3] A skull window was employed by Ackerman[1] in 1858. Magnifying glasses and microscopes were used with and without windows. Jacobi and Magnus[12] photographed pial vessels of dogs through an open trephine hole.

A second method for studying the circulation of the brain and its vasomotor control has been by measuring blood flow. Changes in venous pressure have been recorded[4] as an index flow.

Combined methods of recording both arterial and venous pressures have been used. The speed of arterial flow was measured by Jensen[13] using a stromuhr, who concluded that vasoconstriction occurred. Gesell and Bronk[9] used a thermoelectric method in recording flow in the carotid and femoral arteries. In 1936 Schmidt[19] found the rate of flow reduced in the parietal cortex of the cat during stimulation of the vagus and believed this due to vasoconstriction. Histologic studies using various staining technics by Huber,[10] Hunter,[11] Robertson,[18] Obersteiner,[16] Stohr[22] and McNaughton[14] have shown nerve fibers on the pial arteries.

The studies of Wolff and Forbes[33] in 1928 who photographed the pial vessels through a glass window served to clarify this rather confused subject. They concluded that the circulation of the brain is not regulated wholly from a distance by splanchnic and systemic vasomotor control.

Forbes and Cobb[7] in 1938 added the conclusions that an intracerebral regulation of flow exists; that chemical agents and CO_2 play a major part; that constrictor nerves are present about one-tenth as effective in the pia as in the skin; that vasoconstrictor nerves are distributed unequally to different parts of the brain and that vasodilator nerves are present. The flow is remarkable for its steadiness since capillaries are always open and arterioles do not change size appreciably.

In 1939 Villaret and Cachera[27] published a monograph on the subject of cerebral emboli and documented by still photographs the result of their comprehensive study. They have reported both acute vasoconstriction and enduring vasomotor responses generalized and localized to emboli (pumice, glass, wool). Dogs anesthetized with chloratosane were used for study.

The response of the pial vessels of the monkey under pentothal anesthesia to fatty emboli appears to be different from the findings of Villaret and Cachera[27] with respect to particulate matter. Even particulate matter in our

experience has as yet failed to result in "intense arterial constrictions" either local, in direct contact to the embolizing substance or "at a distance" either transient or "prolonged" (days).

The presence of large emboli within the venous circulation of the pial vessels seconds after injection into the carotid artery was of interest. These were visible as they rapidly traversed through large veins (150 microns). They varied in size, some being at least 25 microns in diameter. Passage into the veins seems possible if the capillaries distend and the emboli elongate. Arteriovenous shunts would provide an alternative means. Swank and Hain[23] in a pathologic study of emulsified paraffin stained with lamp black found the capillaries and small arterioles "capable of considerable dilatation" to account for the passage of many emboli 17 to 35 micra in diameter and possibly some as large as 60 micra. These authors "diligently looked for shunts but found none." They stated that the capillary bed, readily able to dilate, may function as a massive arteriovenous shunt.

As surgeons, our responsibility concerns the diagnosis or treatment of fatty emboli involving the brain.

Whether the patient with a fractured femur and a head injury has a subdural hematoma or a cerebrovascular syndrome caused by fat emboli is often a perplexing problem. Exploratory bone openings have often been used in the past to reach an exact diagnosis.

A more satisfactory method, we believe, is the use of angiography. By means of contrast media (thorotrast, diodrast), the arterial system of the hemisphere can be visualized. An extravasation can then be identified and the patient operated upon as indicated by these studies.

Since normal angiographic patterns are present in those patients having cerebrovascular syndromes from fatty emboli, these patients are spared surgical exploration.

SUMMARY

1. Cinemicrophotographic studies, through a port in the skull, were made of the response of the pial circulation in the monkey to emboli.

2. Dynamic effects upon vessels of from 200 to 20 micra were recorded.

3. Neither a generalized nor localized vasoconstriction was observed to occur in the vessels studied.

4. Arteries and veins expanded segmentally as globular and elongated fat particles traversed the vessels. This expansion permitted passage of an embolus much larger than the vessel involved.

5. Emboli appeared in the large veins (150 micra) seconds after their appearance in the arteries. Many were of large size (25 micra). Dilatation of the capillary bed or arteriovenous shunts may permit the passage of emboli from the arteries to the veins.

6. Through the application of this tool, perfected to permit higher magnification, more information concerning cerebral blood flow should become available.

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Multiple Internal Wire Fixation of Facial Fractures

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MULTIPLE wire pins are an important addition in the fixation of severe, open, comminuted fractures of the face and jaw or total facial crushes after reduction has been accomplished. They have been used in combination with other methods of immobilization, as antral packs, interdental wires or direct wiring of fragments. Solid union has resulted and subsequent bone graft avoided, in spite of other complicating factors, as widespread opening into the mouth, multiple small fragments of questionable blood supply, maximum displacement of fragments with understandable difficulty of alignment, and particularly in those instances in which a protracted delay in reduction and fixation has been necessary. Necessity for tracheotomy is reduced. Use of expensive, complicated, cumbersome traction apparatus or external forms of unsteady fixation are avoided.

Reduction, other methods of fixation and general considerations in the repair of compound facial injuries have been previously recorded and are stated here only for completeness.

Time for repair of a compound facial injury is determined by the patient's *general condition*. The facial repair should be done as soon as the blood pressure becomes stabilized if there are no other complicating factors. It is very difficult to reduce fractures of the facial bones after a lapse of more than ten days following injury. A careful, complete physical examination will determine the necessity for the advice of a neurosurgeon as to the extent of brain damage. Repair of thoracic, urologic, or abdominal trauma, or treatment of fractures of other bones may temporarily require postponing definitive treatment of the facial damage. Protection against the development of tetanus is routinely given.

Diagnosis of facial injuries can usually be made on history, observation and examination. X-rays are routinely taken for confirmation and possible medicolegal purposes. Postero-anterior, right and left lateral are the most useful for suspected fractures of the mandible. A postero-anterior view of the middle third of the face should show the orbital borders.

General endotracheal anesthesia is desirable if the patient's condition permits, or novocain block of the major divisions of the fifth cranial nerve can be done.

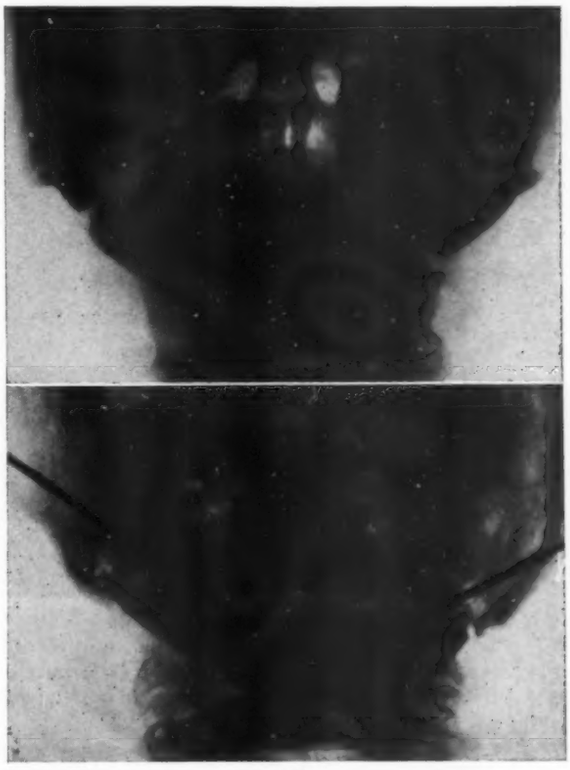
Soft tissue lacerations and tears are carefully closed with fine sutures close to the edge of the wound, after the wounds are copiously irrigated with normal saline and the surrounding area cleansed with soap and water. Minimal *débridement* of facial wounds is done to preserve features. Areas of questionable blood supply are left for removal later, rather than primary excision of something that might have survived, particularly parts of features. Soft tissue repair is begun with the approximation of known points. Where no such points are recognizable, closure is accomplished by successive bisection of the open wound. *Soft tissue avulsions* are repaired by partial closure if necessary and a skin graft to secure a healed wound. Addition of tissue into the area may best be done subsequently, however. Distortion of features is avoided.

FRACTURES OF THE MANDIBLE

Complicated fractures of the mandible can be stabilized, after reduction, by internal wire pins driven across the fracture sites. Reduction is accomplished when the patient's teeth can be brought into normal occlusion. For uncomplicated mandible fractures, interdental wiring, with the teeth in occlusion, is the simplest method of fixation. Solid union is expected, however, with multiple internal wire pin fixation, in spite of such complicating factors as delay in treatment, widespread exposure of

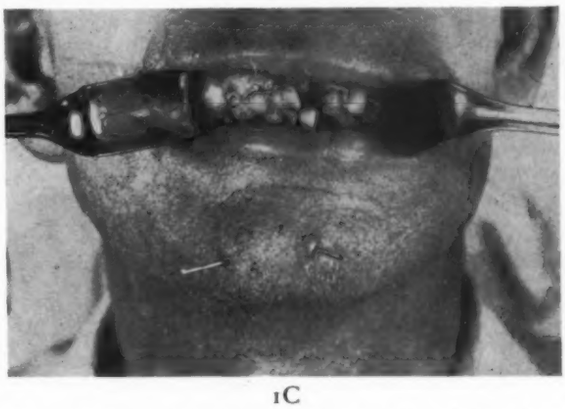
bone into the mouth, extensive comminution, or when teeth are not available or satisfactory for use in fixation, as shown in Figure 1, and in the edentulous jaw. Figure 1A shows the wide separation at the fracture lines near the angles of the jaw with the dropping down of the large separate central fragment. There were no teeth in the two posterior sections for fixation. Reduction is held with multiple wire pins driven with a power drill across the fracture lines, as shown in Figure 1B. Tracheotomy was unnecessary in the postoperative period with immediate solid fixation of a large loose central fragment thereby stabilizing the tongue. Additional support is afforded by No. 24 steel wires between the few available carious teeth. Minimal reaction to internal wire pins is shown at four weeks time. (Fig. 1C.) Interdental wires were removed at this time and the patient allowed to eat most foods. There was solid union at ten weeks when internal wire pins were easily removed.

1A



1B

FIG. 1A and B. A, x-ray showing compound comminuted fracture of mandible with separation of fragments and inadequate teeth for fixation. B, x-ray after reduction and fixation with multiple internal wire pins driven across fracture site. Available teeth also used.



1C

FIG. 1C. Usual minimal reaction to wire pins at four weeks when interdental wires were removed and normal eating was possible. Solid union at ten weeks when wire pins were removed.

MIDDLE THIRD FACIAL FRACTURES

Multiple wire pins afford additional support in the fixation of complicated middle third facial fractures. (Figure 2 will be referred to as part of the text.) This patient was found lying in the highway after an automobile accident. (Fig. 2B.) After a complete careful physical examination, a period of observation and general supportive therapy, repair of the facial damage was performed. As an initial point of solidity in this completely loose, crushed face the larger fragments of the fractured and dislocated zygomas were reduced from inside the antra and held with multiple internal wire pins driven across the face, as are seen in the x-ray. (Fig. 2A.) Entrance to the antra was then made in the buccal fornix through a fracture line. The multiple smaller fragments of the antral walls and orbital floors could then be elevated, "mulched" and held into the best possible position around balsam of Peru iodoform packs in the antra. Diplopia and distortion of the face were avoided. The bones of the nose were pulled up out of the face, and after accurate soft tissue closure the canthal regions were reconstituted. Permanent flatness in this area and blockage of the lacrimal apparatus are usually avoided by this initial reconstitution and fixation. The nose itself was supported on steel wires passed beneath it and anchored to lead plates on each side, as can be seen in Figure 2A. This fixation acted as a sling and in turn rested on the maxilla, previously stabilized with wire pins. Tears of the lips require careful closure on both the skin and mucosal surfaces.

2A

FIG. 2A. X-ray showing multiple internal wire pins driven across both fractured and dislocated zygomas, after reduction. Smaller fragments "mulched" into position and packs in both antra; nose held by wire sling anchored to lead plates on sides.

2B 2C

FIG. 2B and C. B, complete middle third facial crush. Soft tissue carefully closed and features reconstructed. C, result of initial repair.

The patient's appearance is shown in Figure 2C several months after the initial operation.

Transverse fractures of the maxilla or those extending up into the orbit can be fixed after reduction with multiple internal wire pins. If possible the pin can originate in any solid point in the face and act as a cantilever to support the loose portion. In extensive crushes of the face wire pins have held loose sections together well enough to insure union. Separate alveolar or palate fractures have been stabilized only with wire pins or used in conjunction with interdental wiring if teeth were available.

A comfortable pressure dressing aids healing

of damaged soft tissue and fixation of the fractures. Sterile cotton mechanics waste over fine mesh grease gauze, around which a gauze bandage is wound for counter pressure, is readily available and easily applied.

SUMMARY

Multiple wire pins have given simple, direct fixation adequate for solid union in severe compound facial injuries or crushes alone or in combination with other methods. Complicated, expensive, cumbersome external apparatus for traction or fixation is avoided.

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DISCUSSION OF PAPERS BY DRS. VORIS, BY WEBSTER, MARTIN AND GURDJIAN, AND BY BROWN AND FRYER

Joseph E. J. King (New York, N. Y.): I should like to confine my remarks to Dr. Voris' paper, "Skull Defects and Their Repair."

In 1919 I read a paper on cranioplasty before the Southern Medical Association and later made some brief remarks on the subject in a paper in 1922 at the meeting of the Medical Society of the State of New York. The facts presented in the papers were based on experience obtained with war injuries in a hospital in Germany in 1915 to 1917, in the neurosurgical services at Cape May and Fox Hills in the First World War, and civilian cases at Bellevue, Lawrence and other civilian hospitals.

We had a great many cases of skull defects resulting mostly from operative procedures performed in France, many by Dr. Cushing, and returned to us in this country. At that time I stated that the osseous periosteal transplant removed from the tibia was the one of choice. I still hold to this belief, augmented by a number of cases encountered in private practice since World War I.

I stated then that, in general, cranioplasty will likely prove to be followed by better results in civilian practice than in military service, owing to the following factors: First, the patients are operated upon earlier, and therefore a better chance of primary healing of the wound is present. This, in turn, allows for earlier repair of the defect before the cicatrix and adhesion about the defect have become too firm.

Second, in civilian life there is a relatively greater proportion of simple depressed fractures with loss of bone substance than in the military service. These cases in which there is an extradural hemorrhage, without severe brain damage and laceration of the dura, are the most ideal for cranioplasty.

Third, conversely, there is a smaller percentage of patients associated with through-and-through gunshot injuries and other destructive brain lesions, which result in marked gliosis and mental deterioration.

These facts are true today and, remember, in those days we had no antibiotics or sulfonamides.

I like the osseous periosteal tibial transplants because they can be readily cut and obtained from the patient, easily fitted into the beveled margins of the defect, become a living, permanent part of the skull and never have to be removed. Furthermore, all of them take. In over one hundred cases we have never lost a graft, except one, and there was no mortality.

All defects, in my own experience, could be closed by one or multiple transplants from one or both tibias, with the exception of one colored woman in whom an enormous defect remained following the removal of a low-grade malignant tumor of the orbit and frontal bone, in which I used a tantalum plate on account of the enormous size of the defect and the multiple curvatures of the skull. On the whole, I do not think foreign bodies of any kind should be placed in these defects, such as tantalum, vitallium, celluloid, and so on, except in a few cases of extremely large defects and multiple curvatures. The fact that many of these plates have been removed since World War II substantiates this opinion.

Cranial defects created by the surgeon in which both pericranium and the dura have been preserved will not, for the most part, have to be repaired because the defect will fill in itself after two and one-half or three years, both of these membranes being osteogenetic. When both the pericranium and dura have been sacrificed, the defect will not close. This has been our experience with defects following operation for brain abscess. In the days when we had a number of cases of extensive osteomyelitis of the skull, more especially in youths, and the dura and pericranium had been preserved, the defect became closed over with good bone in from two and one-half to three years so that cranioplasty was never indicated. Immediate plating is useless and risky.

William M. Adams (Memphis, Tenn.): I am always glad to hear anyone present a paper on the treatment of facial fractures using some form of internal wiring or pin fixation.

When I read my first paper on internal wiring fixation of facial fractures fourteen years ago, I hoped that within a few years we would not see any more facial fractures treated with the complex

Goldberg external appliance attached to head caps. I am sorry to say, however, that even today quite a number of patients are treated by the use of this cumbersome, antiquated method. When Kisrchner wires or pins are used and left protruding on the outside of the skin, this is not in the true sense internal fixation.

There is one point I would like to emphasize: When you are presented with a facial fracture, you should try to visualize these fractures as those of a skull without any overlying soft parts; this will automatically make it a simple problem to know where to immobilize the movable fractured bone to the nearest unfractured neighboring bony structure.

Only two anatomic points of incision are needed for easy access to any fracture of the maxilla and zygoma. These points are the central portion of the infra-orbital ridge and immediately over the zygomaticofrontal suture line. The incision is ordinarily less than 1 inch in length.

Through an incision at the zygomaticofrontal suture line, using a small male urethral sound, it is very easy to elevate the zygomatic arch and zygoma. In the event that the zygoma has to be immobilized to the zygomatic process of the frontal bone with a wire ligature, it can be carried out through the same incision. This is a distinct advantage over an incision in the temporal region as in the Gillis approach. Also, if the maxilla must be supported, a separate wire ligature can be inserted into the zygomatic process of the frontal bone, carried downward and behind the malar bone, brought out through the upper sulcus and attached to the upper premolar teeth.

In an occasional case of complete fracture of the maxilla after reduction of the maxilla to its normal position, the fractured parts remain quite stationary. In a case of this type it may not be necessary to use any internal wiring or pin fixation. This is most likely to be in the case of an edentulous patient, since it is not as essential to have millimeter accuracy in the bony fixation of an edentulous patient as it is in a patient with teeth.

JOHN E. WEBSTER (Detroit, Mich.): Dr. Voris has asked me to comment about his paper, which I liked very much, and I think he has brought this subject of cranioplasty up to date which it needs every few years.

I might mention, in our experience, that after the last war, we found at the Veterans Hospital that we had to remove about four tantalum plates. It has been reported that there were about 2,000 tantalum plates inserted in skulls as a result of World War II. We wondered how many were being removed. Therefore, we wrote to various veterans' facilities about the country and found that a total of about fifty-two plates had been removed in 1947. Subsequently, Dr. James C. White, of Boston, in 1948 surveyed army, navy and veterans' facilities and found that a total of about 151 alloplastic plates were involved in complications, so that it would seem that tantalum is a very excellent material to use.

Recently, as Dr. Voris has done, we have been using Spence's resinous methyl methacrylate with which one makes a plate much like a dentist makes a set of false teeth. It is very simple; the contouring particularly in the frontal area is very satisfactory. It remains to be seen how well this material will do, but it appears that almost anything can be put in the skull and it will do quite nicely.

HAROLD C. VORIS (Chicago, Ill.): I enjoyed Dr. Webster's movie tremendously. I think that he and his associates are to be commended on that presentation. Perhaps we are going to have to stop talking so loosely clinically about cerebral vasospasm. It may not occur as often as we are inclined to say it does.

There was so much to see in that motion picture, and it went so fast that I could not tell whether in the movie there was any demonstration of a direct communication between arteries and veins or not, and I should like to ask Dr. Webster if he has seen such communications during his studies. He spoke of references to the absence of that in the literature, and I wondered what his direct observations were.

I want to thank Dr. Webster and Dr. King for their comments on my paper and to apologize to Dr. King for not having received a copy of my paper beforehand. However, it was obvious that he did not need it. His discussion was not prearranged, as far as I am concerned, but you can see how wise I was not to attempt to discuss the history of cranioplasty. He was able to give us some very interesting details about the historical aspects of that, at least in this country. I think anything further I had to say about autogenous versus alloplastic grafts would be repetitious. Dr. King presented the case for autogenous grafts very well.

Expendable Bone

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IT has long been the objective of the surgeon of trauma to restore normal anatomy and function to the injured part. Normal anatomy and function are still the prime aims of the surgeon of trauma. This hypothesis is fundamentally correct and should not be abandoned whenever the best possible function can be obtained by anatomic restoration.

There are, however, many instances when normal anatomic restoration is initially impossible; or when it is accomplished, the normal healing processes produce conditions which are not compatible with normal function.

In 1947 a paper entitled "Surplus Parts of the Skeleton" was presented to the American Association for the Surgery of Trauma by the late Fraser B. Gurd. It was this presentation which stimulated the present study. Gurd defined sixteen surplus parts of the skeletal system. These included: (1) clavicle, (2) acromion process, (3) head of the humerus, (4) lateral condyle of the humerus (capitellum), (5) medial epicondyle of the humerus, (6) olecranon, (7) head of the radius, (8) distal fifth of the ulna, (9) carpal scaphoid, (10) carpal semilunare, (11) meniscus of the knee joint, (12) head of the fibula, (13) patella, (14) rib cartilages, (15) ribs and (16) coccyx.

This presentation included experience with some of the parts listed by Gurd and, in addition, the excision of other areas of the skeleton which was done through both choice and necessity. It is to be emphasized that the sacrifice of bone should be applied only for those lesions which experience has proved difficult to treat by more conservative means and in which the result of conservative treatment is poor.

THE CLAVICLE

The entire clavicle or any portion of it can be excised without causing any disability. If the excision is subperiosteal, regeneration will be complete.

The function of the clavicle is little understood and several concepts of function have been advanced. The clavicle acts as a strut to support the scapula. In cases of congenital absence there is apparently no limitation or deficiency of scapular or shoulder function which can be demonstrated. This would lead one to believe that the strut mechanism gives very little support to the shoulder joint.

In addition to acting as a strut for the shoulder girdle the clavicle acts as an anchor for the several muscles which attach to it, the largest of which are the sternocleidomastoid and the trapezius. These muscles, because of their natural pull, tend to elevate the clavicle.

It has been stated that the clavicle holds the shoulder girdle up partially by means of the collateral ligaments of the acromioclavicular joint, but mainly by the conoid and trapezoid ligaments. Whenever there is complete dislocation of the acromioclavicular joint associated with complete tearing of the aforementioned supporting ligaments, the clavicle becomes elevated and the scapula is depressed. This depression of the scapula may be more apparent than real. Portions of the clavicle have been excised for the following:

A. The outer end:
   1. Complete acromioclavicular dislocation, fresh, old
   2. Osteoarthritis of the acromioclavicular joint
   3. Comminuted fracture of the outer one-third of the clavicle with extension of the fracture into the joint

B. The inner end:
   1. Recurrent dislocation of the sternoclavicular joint
   2. Old unreduced dislocation of the sternoclavicular joint
   3. Osteoarthritis of the sternoclavicular joint

C. Total excision:
   1. Osteomyelitis of the clavicle

FIG. 1. Left, arthritis of acromioclavicular joint. Right, resection of the outer end of the clavicle relieved symptoms.

Arthritis of the Acromioclavicular Joint. Arthritis is a common disorder of the acromioclavicular joint causing mild to moderate disability of the upper extremity.

It may develop as a result of repeated trauma, previous separation, fractures of the clavicle with extension into the joint, or in conjunction with arthritis elsewhere in the body.

Pain may be the only symptom. The pain usually originates in the shoulder joint and radiates down the arm. Occasionally the pain may be intermittent and severe, causing it to be confused with the pain of coronary insufficiency.

Point tenderness may be the only positive sign and should lead one to suspect arthritis, which can be verified by x-ray in some cases.

It is not always possible to demonstrate any gross or microscopic pathologic condition. It is postulated that there is some disturbance in the normal anatomic relationship which may be caused by one episode of trauma.

Pain can be relieved by conservative measures. This relief usually is only temporary since the cause of the pain is the roughened surfaces of the clavicle and acromion process rubbing against one another. The symptoms will recur once the patient returns to normal activity.

Complete permanent relief can be obtained by resection of the outer end of the clavicle. This procedure separates the two roughened surfaces so that they can no longer rub against one another.

E. P., a forty-four year old manager of a company, was admitted to Hurley Hospital on February 3, 1951, with a chief complaint of pain in his left arm. For several years previous to admission he had had sharp and disabling pains in the left shoulder which radiated down the left arm. On February 2, 1951, the patient sustained such an attack which lasted for forty minutes and was associated with numbness and tingling of the entire left side of the body. At the same time he had pain in the lower left hemithorax. There was no shortness of breath, weakness or sweating. This attack came on while the patient was at rest, as did most of the previous attacks. In 1940 the patient had received an undetermined type of injury to the left shoulder.

Physical examination was normal except for direct point tenderness over the left acromioclavicular joint. The outer end of the left clavicle was felt to be larger than the right. X-ray examination showed an old healed fracture of the outer end of the left clavicle with a spur projecting toward the coracoid process. There was hypertrophic arthritis of the cervical and dorsal spine.

On February 8, 1951, the distal 2 inches of the left clavicle were excised. The articular surface of the clavicle showed signs of hypertrophic arthritis. A chronic fibrotic tissue covered the joint.

A complete range of motion of the shoulder was obtained within three weeks. There was no residual weakness, deformity or pain in the shoulder and there has been no recurrence of the preoperative symptoms. (Fig. 1.)

R. DuF., a twenty-two year old man, sustained partial separation of the acromioclavicular joint along with other injuries when he fell from a motorcycle on December 24, 1948. This acromioclavicular separation was internally fixed with wire loops.

Subsequent to the fixation, pain and swelling of the acromioclavicular joint developed, with radia-

tion of pain down into the arm. X-ray examination revealed traumatic arthritis. The distal end of the clavicle was excised on November 3, 1949, with complete relief of symptoms.

L. O. S., a sixty-nine year old carpenter, stated that five months previous to admission he had fallen from a scaffold a distance of 10 to 15 feet, landing on his shoulder. He incurred immediate pain and swelling in the shoulder and sustained an acromioclavicular separation without fracture. The arm was immobilized by external fixation for six weeks and he returned to work. He was unable to carry out his duties because of persistent pain on abduction of his shoulder.

On October 13, 1950, the distal 1½ inches of the clavicle were excised. Moderate hypertrophic changes involving the acromioclavicular cartilage were present. Complete symptomatic relief was obtained.

R. W., a twenty-eight year old switchman, was admitted to Hurley Hospital on April 4, 1951, with the chief complaint of pain in the right shoulder which radiated down the arm. This pain had been intermittent for many months. During the past few months the pain had become more severe. It was aggravated by motion and disabled the right shoulder. There was no history of injury to the shoulder. Physical examination was essentially negative except for direct tenderness over the acromioclavicular joint. Acromioclavicular arthritis was demonstrated. There were also arthritic changes in the other joints.

On April 5, 1951, the distal ¾ inch of the clavicle was excised. The patient was discharged from the hospital on April 10th with complete relief of preoperative pain. This pain has not recurred.

Separation of the Acromioclavicular Joint. Excision of the distal end of the clavicle for complete separation of the acromioclavicular joint may be preferable to reconstruction. This is particularly true in men who have to perform physical labor for a livelihood. It will lessen the period of disability and obviate the late complication of acromioclavicular arthritis. With this type of management they are able to return to work in two or three weeks. In women excision of the distal end of the clavicle probably should not be performed as a primary procedure. A complete separation with tearing of the conoid and trapezoid ligaments will result in a high-riding clavicle which may preclude the wearing of a strapless evening gown. Reconstruction of the acromioclavicular joint should be considered since this will yield a better cosmetic result. However, the scar from the reconstruction procedure may be just as noticeable as the displacement of the clavicle.

A. W., a thirty-six year old Negro man, sustained a complete acromioclavicular separation in an altercation in June, 1951. Resection of the distal 2 inches of the clavicle was carried out as a primary procedure. He was able to return to work within three weeks from the time of the injury and is now asymptomatic. (Fig. 2.)

Dislocation of the Sternoclavicular Joint. Dislocations of the sternoclavicular joint, whether recent or old, contribute to considerable disability. The most common complaint is that of pain radiating to the neck which is aggravated by physical labor.

The objective findings in these cases are usually manifested by swelling, and direct pressure will reproduce the pain in the neck. Considerable deformity may be present if the reduction in old cases has been incomplete.

The inner end of the clavicle may occasionally dislocate whenever the shoulder is pushed forward and may reduce when the shoulder is pulled back.

Excision of the proximal end of the clavicle will reduce the deformity and yield an asymptomatic shoulder function.

This method of management is easier, eliminates the prolonged period of immobilization of the shoulder, returns the patient to work in a short period with full shoulder function without the necessity of physiotherapy, and there is no noticeable resulting anatomic deformity. Full physiologic function is obtained.

W. E., a forty-seven year old white man, was injured in an automobile accident on March 19, 1954, and sustained a dislocation of the right sternoclavicular joint and partial separation of the right acromioclavicular joint. These were managed conservatively. Subsequently the patient had a rather severe pain which radiated into the neck and a second pain which radiated down the arm. Following conservative measures he obtained a full range of asymptomatic motion of the right upper extremity. After he returned to work there was a recurrence of these pains which became more persistent and were so severe that he was unable to carry out his duties as a machine operator. On June 3rd the medial 1½ inches and the lateral 1½ inches of the clavicle were excised. There was immediate relief of pain in the neck and the pain which extended down the arm. This patient is able to carry out a full hard day's work without incurring pain during the perfomance of his duties.

V. H., a forty-three year old white delivery man for a food wholesale company, fell on his right shoulder on January 14, 1953. At the time of injury he noticed a large knot in the region of the right sternoclavicular joint. This was treated by conservative measures. Following his return to work, particularly when he was lifting heavy packages, he would notice that the collarbone slipped out of place at its medial head.

On physical examination the right sternoclavicular joint could be dislocated and reduced at will. The patient also complained of radiation of pain into the neck. On February 23rd the proximal 1½ inches of the right clavicle along with the contents of the sternoclavicular joint were excised. Immediately after the operation there was a cessation of pain which radiated into the neck. The patient returned to work at the end of four weeks. At the present time he is able to carry out his full duties as a delivery man. He lifts heavy packages weighing up to 110 pounds or more. He has no pain in his shoulder or neck. There is no pain in the region of the sternoclavicular joint and no limitation of shoulder function. (Fig. 3.)

Fractures of the Clavicle. Excision of the distal end of the clavicle for fractures involving the outer one-third of the clavicle may be perferable to reconstruction for two reasons.

Whenever there is gross comminution of the outer end of the clavicle with fracture lines extending into the joint, the usual process of healing will result in a roughened distal end of the clavicle and production of acromioclavicular arthritis due to callus. Whenever such a condition is present, excision of the involved segment of the clavicle will yield excellent shoulder function in a minimum of time.

The second reason for excising the distal end of the clavicle for fractures is purely economic. While eight to ten weeks of disability is not excessive, it is considerable to the person who is affected. The usual disability after excision of the distal end of the clavicle is two weeks. If the trapezoid and conoid ligaments are intact, there will be no resulting deformity which is noticeable even upon close inspection. If they are not intact, the proximal portion of the clavicle will ride high. This will cause no functional disability. The following two patients returned to work within two weeks after their injuries.

H. T. W., a thirty-three year old Negro man, sustained an oblique fracture involving the distal end of the clavicle with the proximal fragment penetrating the trapezius muscle and almost perforating it on June 5, 1949, when he was hit on the shoulder with a bottle. Closed reduction was impossible because of intervening muscle in the fracture site. The distal fragment was excised and the sharp edges of the proximal fragment were removed. The patient was discharged from the hospital on June 13, 1949.

Although the clavicle apparently rode high in the shoulder after excision of the distal end, no disability was present. The patient had no pain and was able to carry out a full day's work in three weeks.

K. V. A., a thirty-one year old white woman, sustained a comminuted fracture of the distal end of the right clavicle with extension of the fracture lines into the acromioclavicular joint when she was in an automobile accident on October 8, 1952.

On the date of admission the distal 2 inches of the right clavicle along with the distal fracture fragment were excised. Full range of motion was obtained in two weeks and the patient returned to work at that time. Since then the shoulder has been asymptomatic. There has been no disability, no limitation of motion or noticeable deformity of the shoulder. (Fig. 4.)

Osteomyelitis of the Clavicle. Osteomyelitis anywhere in the body is difficult to treat. However, in the clavicle it can readily be controlled by excision of the infected portion of the bone. If the resection is subperiosteal, a new clavicle will regenerate. The following two cases are illustrative of the management of osteomyelitis. In one, subperiosteal resection of the clavicle was performed in multiple stages and regenerated a complete new clavicle. In the second case, no subperiosteal excision was done and there has been no regeneration after two years.

L. S., a nineteen year old white male, was admitted to Hurley Hospital in May, 1941, with Ludwig's angina. This was incised and drained. Approximately two weeks later he began to complain of pain over the right clavicle with subsequent abscess formation. The abscess was incised and drained and he continued to have persistent drainage of this shoulder.

A well established osteomyelitis involving a large section of the clavicle was present, and subsequently a pathologic fracture was sustained. Multiple operations were carried out on this clavicle through July, 1941. Multiple sequestra were removed and in all a total excision of the clavicle was carried out in stages. After the removal of all of the clavicle the wound healed and the patient later had a complete regeneration of the clavicle. This

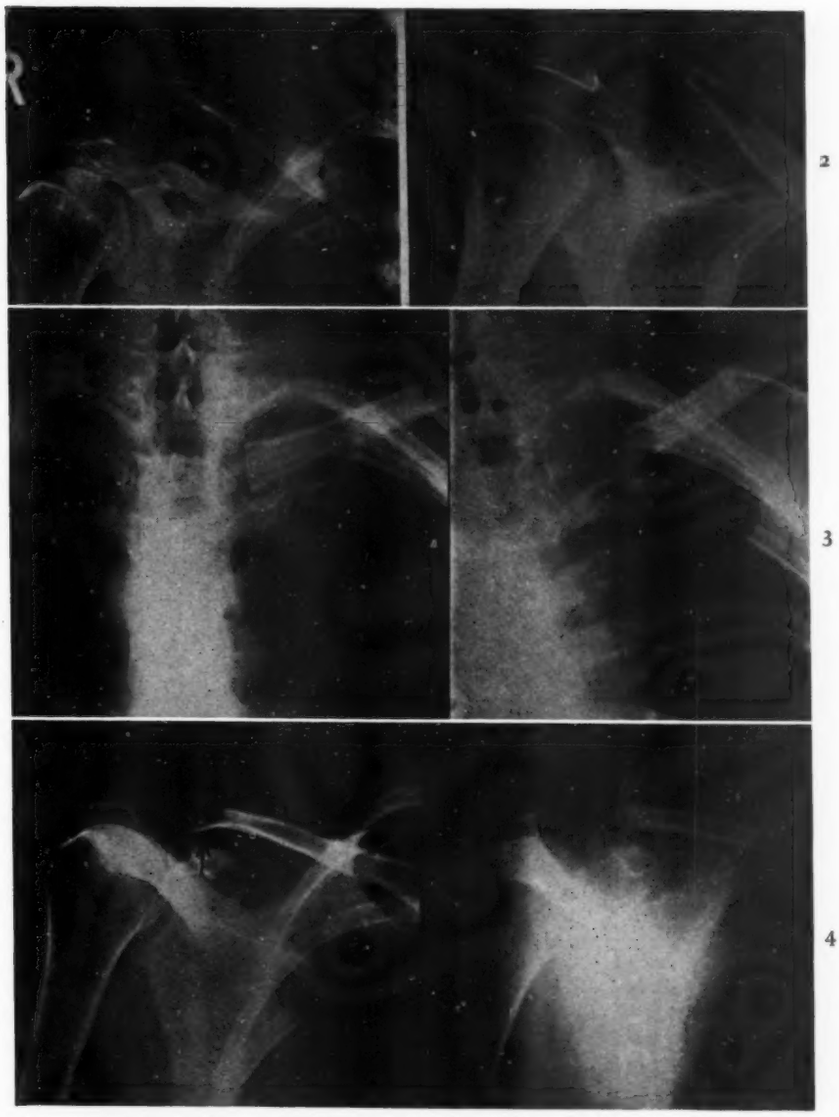

FIG. 2. Left, complete acromioclavicular separation. Right, resection of the outer end of the clavicle produced complete asymptomatic shoulder function.

FIG. 3. Right, recurrent dislocation of the sternoclavicular joint. Left, resection of the inner end of the clavicle relieved symptoms and produced no disability.

FIG. 4. Left, fresh comminuted fracture of the distal end of the clavicle with extension of the fracture into the acromioclavicular joint. Right, resection of the outer end of the clavicle produced an asymptomatic shoulder, an early return to work and eliminated the late complication of acromioclavicular arthritis.

boy was one of Flint's finest athletes. Subsequent to the healing he played basketball, football and bowled. He also coached a high school football and basketball team. He had no residual disability. (Fig. 5.)

P. M., a thirty-six year old white woman, sustained a fracture of the outer third of the right clavicle on July 10, 1951. It was managed primarily by internal fixation with an intramedullary pin. Infection developed at the operative site, which was followed by osteomyelitis and non-union of the fractured clavicle. On March 9, 1952, the lateral four-fifths of the clavicle were resected because of chronic osteomyelitis. She was discharged from the hospital fifteen days postoperatively, with the wound healing without complication and a full range of motion of the right shoulder. There has been no recurrence of the osteomyelitis. At present

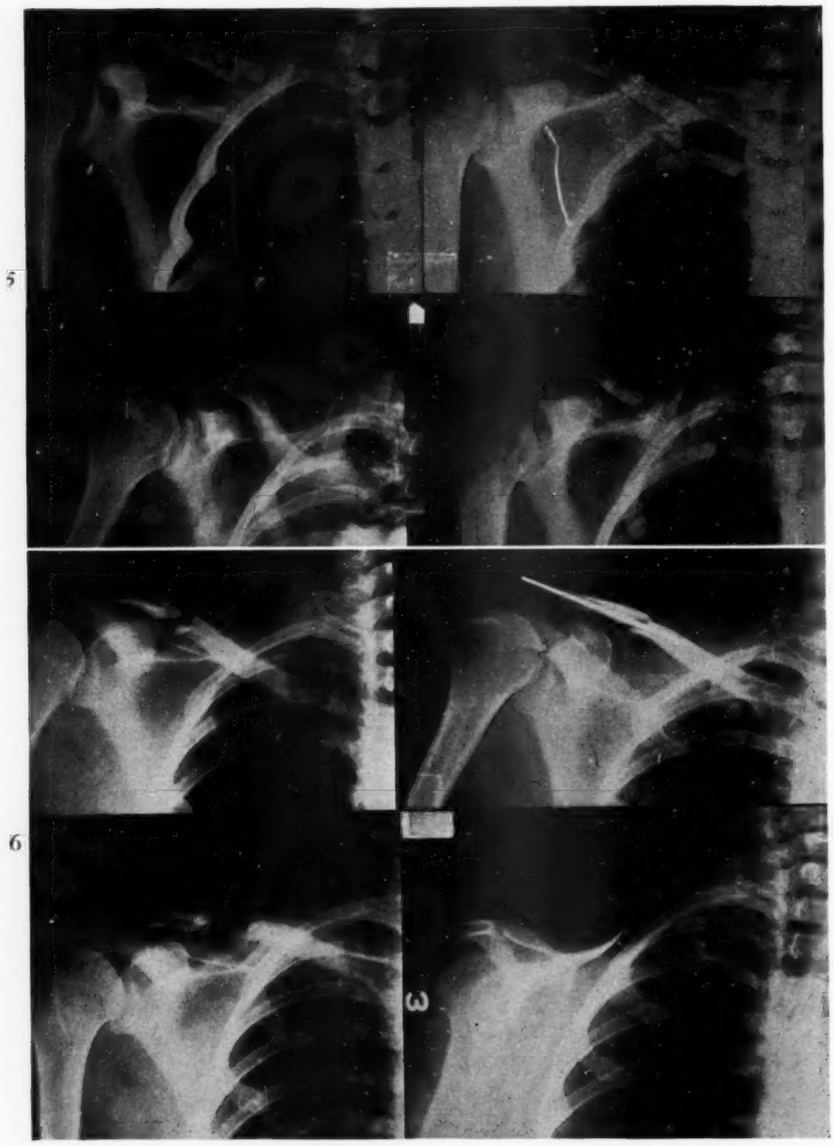

FIG. 5. Upper left, osteomyelitis of the clavicle. Upper right, pathologic fracture. Lower right, complete subperiosteal resection of the clavicle performed in stages to eliminate infection. Lower left, complete regeneration of the clavicle yielding asymptomatic function.

FIG. 6. Upper left, fracture of the clavicle. Upper right, intramedullary fixation. Lower left, osteomyelitis of the clavicle. Lower right, extraperiosteal excision of the lateral four-fifths of the clavicle rapidly eliminated the infection but produced no regeneration of the clavicle. No shoulder disability.

the proximal section of the clavicle pinches the skin during certain movements. In this case the patient would have been better off had the entire clavicle been excised. (Fig. 6.)

THE HEAD OF THE HUMERUS

The head of the humerus is essential for normal shoulder function. Its absence is a severe disability. This is because the normal humeral head acts as a fulcrum within the shoulder joint. When the head of the humerus is lost, there is a distortion of the normal muscular pull with resulting instability and marked loss of the power of abduction.

In certain cases of intracapsular fracture dislocations of the anatomic neck of the humerus, the head of the humerus may be completely detached from all surrounding

tissues. There may develop an aseptic necrosis of the humeral head with eventual ankylosis of the shoulder. For this reason excision of the humeral head and upper end of the humerus may be the procedure of choice.

In the following cases these people, although they have an unstable shoulder joint, are able to place their hands in their hip pockets, and wash their forehead. These actions are painless. However, if strenuous physical labor is attempted, pain is usually the result.

From any standpoint, excision of the humeral head is not particularly satisfactory. Perhaps better results will be obtained by the use of an upper humeral prosthesis such as is now being used by Dr. Charles Neer of New York City, Dr. Gordon Morrison, Boston, Massachusetts, and others.

L. N., a fifty-six year old white man, sustained a fracture dislocation of the anatomic neck of the right humerus in a fall down stairs in October, 1953. The fracture dislocation was reduced by manipulation and maintained by olecranon traction. During the next few days the patient became disoriented because of delirium tremens and tore the traction apparatus apart several times, producing a malposition of the fracture. This malposition could not be corrected by remanipulation. The shoulder joint was therefore explored; the head of the humerus was found to be completely detached from its blood supply and was excised. A section of the greater tuberosity was sutured down to the upper humeral shaft and the arm was placed in a sling. Postoperatively, considerable callus formed at the upper end of the shaft in an attempt to form a new humeral head. At a nine-month follow-up the patient had a 45 degree abduction. There was no limitation of internal or external rotation. The shoulder had been without pain until he tried to do heavy work. After he stopped, the pain disappeared. (Fig. 7.)

G. B. A., a fifty-five year old white woman, sustained a subcoracoid fracture dislocation through the anatomic neck of the left humerus when she was struck by a car on December 8, 1948. A closed manipulative reduction was attempted. This separated the shaft from the head, leaving the head lying free beneath the pectoralis muscle. On December 13th the humeral head was removed, the shaft of the humerus was transected and the shoulder cuff sutured to the lateral margin of the humeral shaft. At a six-year follow-up the shoulder is painless if it is not used for strenuous work. There is approximately 30 degrees abduction through scapular and scapulohumeral action. The patient can reach her forehead and her opposite buttock. She cannot comb her hair but can hang up clothes. (Fig. 8.)

THE ELBOW JOINT

In severely comminuted fractures involving the elbow joint such as may be sustained by a direct fall on the elbow, the entire elbow joint may be excised through both choice and necessity. Some of these fractures are so severely comminuted that a restoration compatible with satisfactory elbow function is impossible. The choice between excision of the elbow joint with the resulting flail elbow or reconstruction with ankylosis of the elbow should be made early, taking into consideration the patient's occupation. If the occupation does not require strenuous use of the arms, excision of the elbow joint should be considered. If, however, the patient depends upon manual labor for a livelihood, reconstruction with the ankylosis taking place in the position of optimum function will be the procedure of choice.

Resection of the elbow joint leaves the patient with an unstable elbow. Full flexion and extension can be obtained but lateral stability is lost. These patients can comb their hair, put their hands in their hip pockets and perform almost any function of the elbow not requiring stability.

If the comminution is limited to the condyles and the radius and ulna are intact, excision of the humeral condyles alone will yield satisfactory function.

If fractures are present in the olecranon process and the head of the radius along with fractures of the humeral condyles, the proximal ends of the radius and ulna should be excised proximal to the insertions of the brachialis and biceps muscles.

D. H., a fifty-eight year old white man, fell on his right elbow on August 3, 1944, and sustained severely comminuted open fractures involving the condylar region of the humerus, the upper end of the ulna and the upper end of the radius. Excision of all the fragments and a squaring of the lower end of the humerus and upper end of the radius and ulna were carried out along with débridement of the devitalized soft tissue.

This man now has a flail elbow. He has full flexion and complete extension but lacks lateral stability. This is a serviceable elbow and the patient carries out the full duties of a janitor. (Fig. 9.)

R. R., a forty-two year old construction worker, sustained a severely comminuted supra- and intercondylar fracture of the right humerus on March 4,

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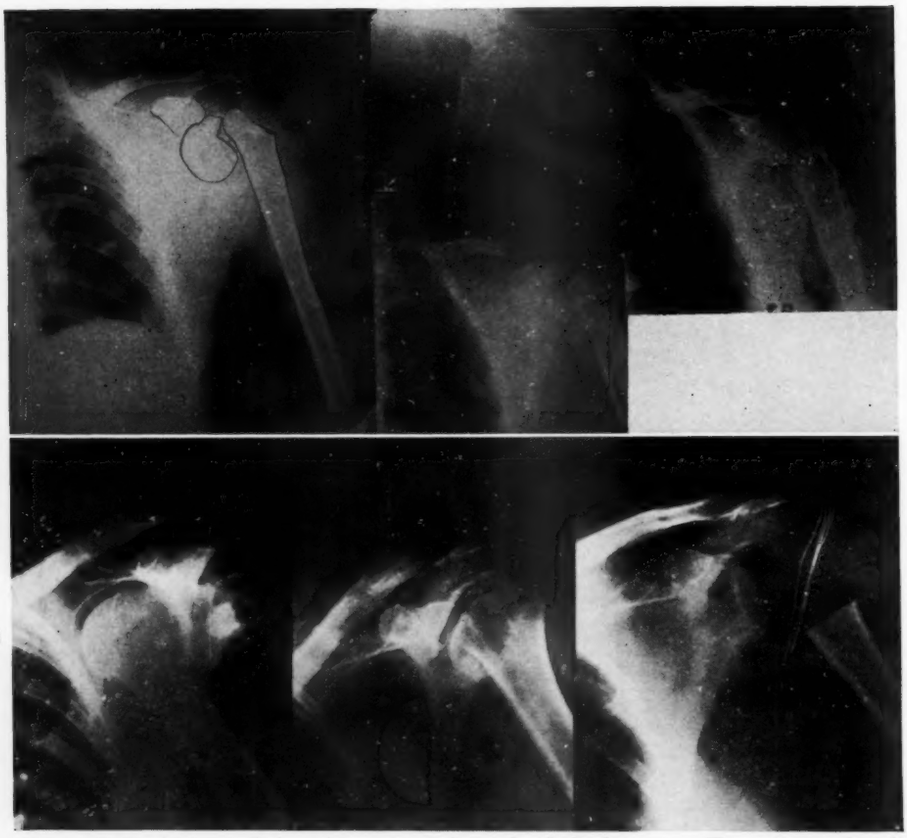

FIG. 7. Left, fracture dislocation, anatomic neck of the humerus. Top center, closed reduction of the fracture dislocation is satisfactory. Lower center, resection of the head of humerus. Greater tuberosity attached to lower fracture segment. Right, healing process attempts to form new humeral head. Shoulder function limited but painless unless strenuous work is attempted.

FIG. 8. Left, fracture dislocation of the shoulder. Center, head of humerus displaced during reduction. Right, resection of the head of the humerus. (Note the insertion of an upper humeral prothesis may have yielded a better functional result.)

1947, when he fell 15 feet. Any type of fracture assembly was impossible; therefore the lower end of the humerus was excised. The elbow is unstable but the patient has full painless motion. (Fig. 10.)

THE OLECRANON PROCESS

The olecranon process along with the proximal one-third of the articulating surface of the ulna may be excised with little or no residual disability. This procedure is preferable to reconstruction whenever there is severe comminution which during the normal process of healing would produce arthritis. Excision of the comminuted segments will yield a satisfactory elbow. The expansion of the triceps tendon extends well down onto the upper aspect of the ulna. If the olecranon is excised through a linear incision extending through the mid-portion of the triceps tendon, very little is needed in the way of repair since the triceps is not completely detached from the ulna and there is a minimal area to heal.

In some intercondylor fractures of the humerus where extension of the ulna is limited because of a distortion of the olecranon fossa, the olecranon process may be excised to increase the range of extension.

C. E., a thirty-nine year old man, sustained a fracture of the left olecranon process in June, 1945. Primary management of the fracture was plaster of paris fixation with the elbow in extension. Following the injury he complained of pain on flexion of the elbow and his hand was swollen most of the time. A complete range of painful motion was present.

This was an ununited fracture of the olecranon process. The ununited segment was excised on June 5, 1946. Full painless function subsequently developed.

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FIG. 9. Left, severely comminuted fracture of all bones of the elbow joint. Right, resection of the elbow produced a full range of motion but instability.

FIG. 10. Left, comminuted supra- and intercondylar fracture of the humerus. Right, late follow-up. Resection of the lower end of the humerus produced some calcification in the joint with instability but satisfactory motion.

J. F., a forty-seven year old man, sustained a comminuted fracture of the olecranon process in an automobile accident on July 17, 1950. On July 22nd the fracture fragments were excised and the triceps tendon was repaired. Full asymptomatic function resulted.

F. W., a thirty-three year old man, sustained a comminuted fracture of the olecranon process when he was struck on the elbow with a board. The fragments were markedly displaced and an adequate fracture assembly was impossible. The fracture fragments which involved nearly all of the articulating surface of the olecranon were removed.

Subsequently the patient had full use of the elbow, with no loss of motion or strength. He was able to do push-ups with the involved arm as well as with the uninjured one at six months post-trauma. (Fig. 11.)

L. Z., a fourteen year old white male, fell on his right elbow eight months before his admission to Hurley Hospital. Since that time he had a 90 degree limitation of extension of his right elbow. The original x-rays showed the olecranon fossa to be a foramen, and there was a depressed intercondylar fracture of the lower margin which partially closed the foramen. Extension was limited because the olecranon impinged on the lower margin of the foramen. In October, 1954, the olecranon process with the proximal one-third of the ulnar articulating surface was removed. At the time of the operation this gained 45 degrees additional extension, and since that time there has been increasing function and motion of the elbow.

THE HEAD OF THE RADIUS

That the head of the radius is expendable has been recognized over many years. In comminuted displaced fractures of the radial head excision has become the customary procedure. Baring the complication of myositis ossificans, the results of the excision of the

FIG. 11. Left, comminuted fracture of the olecranon process of the ulna. Right, resection of the olecranon produced a stable asymptomatic elbow with no loss of function.

radial head are good. Once the decision is made to remove the radial head it should be done expeditiously, preferably within the first twenty-four hours.

ULNA

The distal fifth of the ulna is expendable. Its distal articulation is small and contributes little, if anything, to the stability of the wrist. The ligaments on the ulnar aspect of the wrist are strong and furnish the needed support in the absence of the distal ulna. Its absence causes no disability.

The distal end of the ulna has been excised for an isolated fracture with comminution extending into the joint. This eliminates the possibility of traumatic arthritis with resulting wrist pain. In addition the length of disability is shortened and the patient can return to manual labor within two weeks.

Occasionally fractures of the distal radius and ulna exist in which a distal ulnar fragment blocks the reduction of the radius. If the ulnar fragment cannot be reduced and the reduction maintained, it may be removed through choice and necessity to obtain a satisfactory fracture assembly of the radius.

In old fractures of the distal end of the radius where there has been much comminution, a shortening of the radius with a radial shift of the hand frequently produces pain at the distal end of the ulna. Although this pain usually disappears with time, in those cases in which it is persistent and causes disability it can be eliminated by excision of the distal end of the ulna.

E. W., a thirty-seven year old Negro man, sustained a comminuted fracture of the distal end of he left ulna when he was struck on the wrist with a stick on October 17, 1952. Primary resection of the distal ulnar fragment was performed. The wrist was splinted for ten days. Upon removal of the splint the patient had full asymptomatic function of the wrist and returned to work in two weeks. (Fig. 12.)

R. R., an eighteen year old white male, sustained a fracture of the distal end of the left radius and ulna in an automobile accident on August 14, 1953. The ulnar fracture was through the distal epiphysis and was rotated in between the radius and ulna. The distal radial fragment was displaced dorsally. The wrist was manipulated on two occasions, each resulting in an unsatisfactory reduction because of the position of the distal ulnar fragment which blocked the reduction of the radius. An open reduction of the distal ulnar fracture was attempted but a satisfactory reduction could not be maintained. The distal ulnar segment was therefore excised. The radius was then reduced by manipulation. There has been no resultant disability. (Fig. 13.)

THE CARPAL LUNATE

The carpal lunate is expendable. Its absence causes little, if any, demonstrable disability of the wrist.

Although many carpal lunates remain viable following their dislocation, aseptic necrosis is a common sequel. For this reason it may be preferable to excise the carpal lunate rather than reduce the dislocation.

If the carpal lunate can be reduced by a closed means, there is no reason to excise it. If operative measures are necessary for reduction, it should probably be excised. This is true particularly if it is completely detached from the soft tissues.

Following reduction of a carpal lunate the patient should be kept under observation for a prolonged period. Once it is demonstrated that aseptic necrosis is taking place, the carpal

FIG. 12. Left, comminuted fracture of the distal end of the ulna with extension of the fracture into the joint. Right, resection of the distal end of the ulna shortened the disability to two weeks and produced a firm, stable asymptomatic wrist.

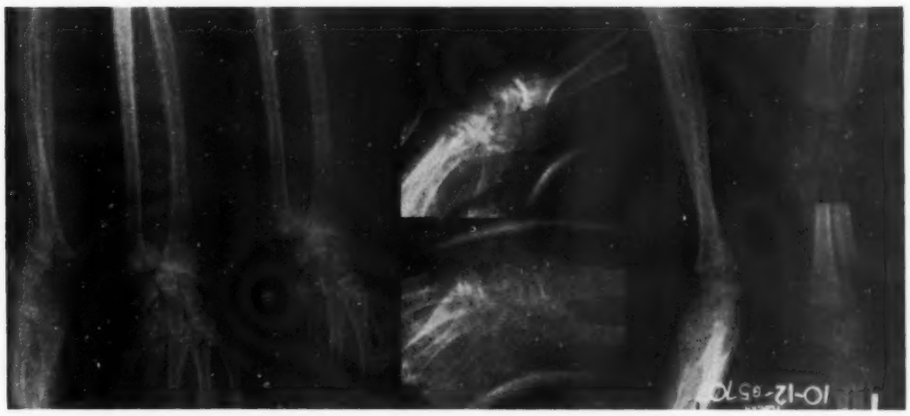

FIG. 13. Left, fracture of the distal end of the radius and ulna with dorsal distal displacement of the fragments. Center, reduction of the radius was blocked by the interposition of the distal ulnar segment. Right, excision of the distal ulnar fragment allowed reduction of the fractured radius and produced no disability.

lunate should be excised without delay. The longer a necrosed carpal lunate is left in place, the more osteoarthritis will develop in the wrist and the less satisfactory will be the result of the excision.

J. M., a forty-two year old white man, sustained a volar dislocation of the left carpal lunate in an automobile accident on November 8, 1950. Manipulative reduction was unsuccessful. Excision followed. There has been no residual weakness of the wrist.

D. McK., a fifty-two year old man, sustained an injury to his wrist when he fell on his hand. However, he thought that the wrist was just sprained and sought no medical treatment. Six weeks later, on July 25, 1948, x-ray demonstrated a volar fracture dislocation of the left carpal lunate. This was excised. The patient has had no subsequent functional disability of the wrist.

14 15

FIG. 14. Left, displaced fracture of the patella with a large intact superior segment. Right, partial patellectomy produced an asymptomatic knee.

FIG. 15. Left, severely comminuted fracture of the patella. Right, total patellectomy produced full asymptomatic function with no disability. It eliminates the late complication of arthritis.

THE PATELLA

The patella is a sesamoid bone and is completely expendable. In its normal state it does contribute considerably to the function of the knee by acting as a fulcrum to increase the quadriceps leverage mechanism. It also has a protective buffer function.

The knee joint, to function normally, requires smooth articulating surfaces. Fractures which damage the articular surface of the patella are prone to destroy its normal gliding action by the production of callus.

When the articulating surface of the patella is rough, the resultant scraping and discomfort will cause an unstable knee and the development of traumatic arthritis. If the condition is allowed to persist, the traumatic arthritis will become progressively more severe with extension to the femoral condyles. The knee will become disabled because of pain and loss of motion.

Patellectomy, either partial or total, should be considered as a primary form of management in all cases of comminuted fractures of the patella with displacement of fragments. If the comminution is limited and a fragment remains amounting to one-half of the patella, partial patellectomy is the treatment of choice. This will not destroy the normal appearance of the knee and will still maintain the fulcrum of the quadriceps mechanism.

If the comminution is generalized and there is not a solid fragment amounting to 40 per cent of the normal articulating surface, total patellectomy should be performed. Total patellectomy disturbs the normal external appearance of the knee by causing a flattening on its anterior side. It also weakens the extension of the knee because the fulcrum is lost. However, this loss is not so great as to cause any disability in normal living.

Although the early results of reconstruction of these comminuted patellar fractures may be satisfactory, the late results are not. These patients may get along fairly well for several years only to end up with severe traumatic arthritis. If the articular surface of the patella is rough, the patella should be excised. The sooner the patella is excised, the better will be the ultimate function of the knee joint.

From a review of 163 cases of patellar fractures, ninety-seven were non-displaced and sixty-six were displaced comminuted fractures. Of this latter group, forty were managed by partial patellectomy and fourteen by total patellectomy. The results of this form of treatment have been satisfactory.

S. H., a fifty-three year old white man, was injured in an automobile accident on March 6, 1946, and among other injuries he sustained a displaced fracture of the right patella. On March 9th fragments of the lower portion of the patella were excised. The infrapatellar ligament and quadriceps expansion were repaired.

FIG. 16. Upper left, fracture of the patella with slight separation of fragments. Upper right, approximation of fragments with wire loops and repair of tendon tears yielded asymptomatic function for eight years. Lower left, severe traumatic arthritis at end of nine years with marked limitation of motion and pain. Lower right, total patellectomy yielded complete extension and 90 degrees of painless flexion.

At the end of three weeks full extension and 90 degree flexion of the knee were obtained. This knee eventually obtained a full range of painless motion with no resulting disability. (Fig. 14.)

N. C., a forty-six year old white woman, sustained a severely comminuted fracture of the right patella when she fell directly on her knee on December 1, 1949. Primary total patellectomy was carried out because none of the fragments were large enough to perform any serviceable function. The supra- and infrapatellar tendons and quadriceps expansion were repaired. At a six-month follow-up full extension of the knee was present. Flexion was present through 120 degrees. The patient was walking without pain, swelling or limp. There was no apparent weakness of the knee. (Fig. 15.)

M. S., a seventy-three year old white woman, was admitted to Hurley Hospital on June 30, 1952, with a chief complaint of pain in the left knee. Nine years previous to this admission the patient had sustained a comminuted fracture of the left patella with separation of the fragments. The fracture of the patella was reduced primarily and internally fixed with wire loops. Following the original surgery the knee was well for approximately eight years, but about a year before this admission she began to complain of some pains in the left knee which became increasingly more severe. These were aggravated by motion and she began to lose the motion in the left knee. At the time of admission she had approximately 20 degrees of flexion.

X-ray examination of the left knee showed marked osteoarthritis involving the patella and femoral condyles. On July 1, 1948, total patellectomy was carried out and exostoses on the femoral condyles were removed. The patient made an uneventful recovery and was discharged from the hospital twenty-six days postoperatively, at which time she had 45 degree motion of the knee without

FIG. 17. Left, fracture of the head of the fibula with detachment of biceps femoris tendon. Right, excision of head of fibula and repair of biceps femoris tendon produced full asymptomatic function.

pain. This motion has subsequently increased to more than 90 degrees and she is still without pain. (Fig. 16.)

THE HEAD OF THE FIBULA

The head of the fibula is not essential for normal function of the knee or lower extremity. The shaft of the fibula does not seem to play a very important role in the function of the leg since large segments are frequently removed for use in bone grafts. Cases are on record in which the entire fibula, including the lateral malleolus, has been excised for osteomyelitis with little resulting disability.

Injuries which result in fractures of the fibular head, especially those with displacement, are apt to be complex. Many of them are associated with a contusion or laceration of the peroneal nerve, partial disruption of the insertion of the biceps femoris, tears of the lateral collateral ligaments of the knee joint and injury to the lateral meniscus. For these reasons operative management is often indicated.

During the repair of these injuries it may be preferable to excise the fibular head rather than reconstruct it. If this is done, the disability will be limited only to that time which is necessary for the soft tissues to heal.

J. McC., a 23 year old white man, sustained an open displaced fracture of the head of the fibula, partial disruption of the biceps femoris insertion, a contusion of the peroneal nerve and disruption of the lateral collateral ligaments of the left knee joint when his leg was pinned between the bumpers of two automobiles on March 6, 1954.

The wound was débrided, the fibular head was excised and the biceps femoris insertion and the collateral ligaments were repaired. Six months after the injury there is no noticeable disability of the knee. There is full painless function and the knee is stable. There are still signs of peroneal nerve palsy but these have continued to improve. (Fig. 17.)

THE MEDIAL MALLEOLUS

Portions of the medial malleolus are expendable. The distal 25 to 50 per cent may be excised without producing an unstable ankle. This procedure may be preferable to a bone graft or other types of surgery in the management of old ununited fractures of the medial malleolus which are in malposition. Excision of the distal portion of the medial malleolus and reconstruction of the deltoid ligament produce a short disability with eventual full asymptomatic stable function.

C. H., an eighteen year old white male, was admitted to Hurley Hospital on March 9, 1935, with a chief complaint of inability to dorsiflex the right ankle because of pain. Six months previously the patient sustained a severe sprain of the right ankle in a football game. After the injury he was able to walk on his foot. However, it became more swollen and caused considerable pain when he tried to dorsiflex the foot. The swelling subsequently disappeared but the pain persisted until the time of his admission. X-ray examination of

the ankle showed an old ununited fracture of the tip of the medial malleolus. This was excised and the deltoid ligaments repaired. Full asymptomatic function of this ankle was obtained.

SUMMARY

Eleven expendable portions of the skeleton have been discussed. These are: (1) the clavicle, (2) head of the humerus, (3) condyles of the humerus, (4) olecranon process, (5) the elbow joint, (6) head of the radius, (7) distal fifth of the ulna, (8) carpal lunate, (9) patella, (10) head of the fibula and (11) medial malleolus. These are not expendable in children.

It is not the intent or purpose of this presentation to recommend the indiscriminate excisions of portions of the skeleton. An attempt has been made, however, to evaluate the usefulness of excision in certain selected cases rather than reconstruction. In many instances the length of disability can be decreased and the late complications of reconstruction reduced or eliminated with no residual loss of function.

The Clavicle and Its Relation to Trauma to the Subclavian Artery and Vein

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ACUTE trauma to the subclavian artery, the subclavian vein and the brachial plexus may result from direct fracture of the clavicle. However, there are additional mechanisms by which this bone may injure these structures. These include mal- and non-united fractures as well as congenital anomalies of the clavicle, and finally, a group of functional syndromes in which the retroclavicular neurovascular structures are intermittently compressed by the clavicle upon the assumption of certain postural positions.

The symptomatology is dependent upon the degree and frequency of compression of the subclavian vessels and the lower cord of the brachial plexus. Although the primary concern of this paper is vascular trauma, the neurologic symptoms should be mentioned. They consist of pain in the shoulder, arm, forearm and hand as well as paresthesias in these regions. The latter symptom is usually perceived in the area of distribution of C8 and T1. Ischemic symptoms secondary to intermittent compression of the subclavian artery include numbness, coldness, weakness and discoloration. More profound degrees of ischemia may result in ulceration or gangrene. The symptoms are most marked in the fingers and hands, although there may be numbness and weakness in the forearm. It is difficult to interpret pain with reference to ischemia. Although direct neural trauma is probably the major etiologic agent, ischemia may also contribute to local peripheral neuritis and potentiate this symptom. Less commonly, the presenting symptoms are those of venous obstruction or occlusion. Characteristically this phenomenon results in edema and cyanotic discoloration of the extremity. Dilatation of the veins of the extremity and about the shoulder are common accompaniments. A considerable number of pseudonyms have been applied to the syndrome of axillary and/or subclavian venous thrombosis, perhaps the most popular of which is "effort thrombosis."[1]

ANATOMIC ABNORMALITIES

Injury to the subclavian artery or vein in fractures of the clavicle is extremely rare.[2] We have not had occasion to see arterial or venous contusion or laceration immediately following fracture. However, the first case to be presented is one in which thrombosis of the subclavian vein followed malunion of a clavicular fracture.

CASE 1. J. R.,* a forty-two year old white woman, sustained bilateral fractures of the clavicle and multiple fractures of the jaw seventeen years prior to the present admission. Six weeks following the clavicular fractures, overriding was noted and bilateral open reduction with fixation of the fragments by kangaroo tendon was performed. A satisfactory functional result was obtained on the right, but the patient noted intermittent discomfort in the region of the left clavicle and shoulder. Four months prior to admission the patient noted that her left arm was larger than the right and that the left arm fatigued more readily than the right. There was no swelling of the forearm or hand, and no paresthesias were noted. The swelling and weakness gradually increased until four days prior to admission when, following a swim, the whole of the left arm became markedly swollen. There was extreme weakness of the extremity and a subjective sensation of coolness.

Examination revealed a malunited fracture of the left clavicle. There were obvious collateral channels extending from the left arm and shoulder to the pectoral region. The whole of the left upper extremity was moderately swollen. Skin temperature of the arms was equal to gross testing. When lying in bed with the arm at the side, the radial pulse was strong. However, upon sitting the radial pulse obliterated with deep inspiration, turning of the head to either side or abduction of the left arm to 45 degrees. X-ray of the clavicle

* Cases I to IV were kindly referred by Dr. Irving S. Wright.

FIG. 1. Case 1. X-ray of seventeen year old clavicular fracture illustrating malunion and overriding of the fragments on the left.

revealed a malunited fracture on the left with significant overriding of the medial and lateral fragments. (Fig. 1.)

At operation the patient was found to have a large number of venous collateral channels in the retroclavicular space. The subclavian vein was felt to be thrombosed. The inner tip of the lateral clavicular fragment was pressing upon the subclavian artery and was apparently responsible for the intermittent compression of this vessel with deep inspiration or hyperabduction. The clavicular fragments including periosteum were resected. Immediately postoperatively it was possible to hyperabduct the left arm to 180 degrees without obliterating the radial pulse. The postoperative course was uncomplicated. The arm was maintained in a position of elevation, and anticoagulant therapy was instituted and maintained for approximately one month. At the time of discharge, seven days following surgery, the left arm measured 2 inches more in circumference than the right. There was no difference in size between the left and right forearms and hands. The patient was fitted with an elastic sleeve. During the follow-up period of fifteen months she has had no pain in the clavicular or shoulder regions and has noted no fatigue or paresthesias in the left upper extremity. It is her impression that the collateral veins over the left shoulder have become slightly more prominent. There has been no evidence of clavicular regeneration. The left arm remains slightly larger than the right. Turning the head, depressing the shoulders, deep inspiration and hyperabduction do not dampen the left radial pulse. (Fig. 2.)

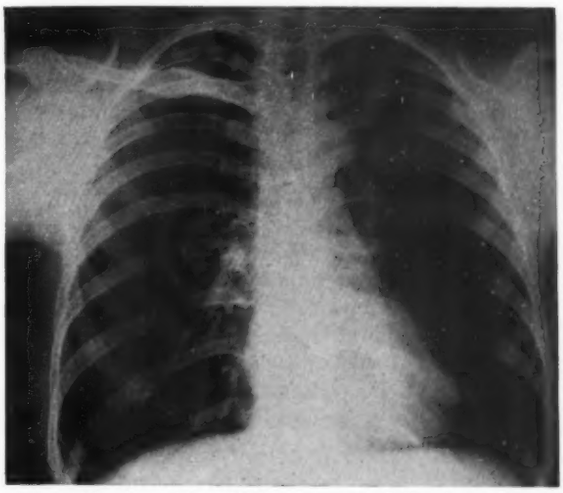

FIG. 2. Case 1. X-ray fifteen months following excision of malunited clavicular fractures which had produced subclavian vein thrombosis and intermittent subclavian artery occlusion. The periosteum was removed at the time of surgery and there has been no bony regeneration.

This case illustrates the advisability of resection of the clavicle when malunion has produced thrombosis or intermittent compression of the subclavian vessels. It is believed that the positional changes which produced obliteration of the radial pulse and the operative finding of compression of the subclavian artery by the tip of the lateral fragment made subclavian artery thrombosis an imminent possibility. Perhaps in the absence of bony compression of the vessels, the procedure of excision of the subclavius muscle and anterior scalenotomy for lessening pressure upon the subclavian vein as advocated by McCleery et al.[3] would have been adequate in this case. Similar cases of neurovascular compression by a malunited fracture of the clavicle which were treated by claviculectomy have been reported by Campbell and his associates[4] and by Pipkin.[5]

The second case illustrates compression of the subclavian arteries by an unusual congenital abnormality of the clavicles.

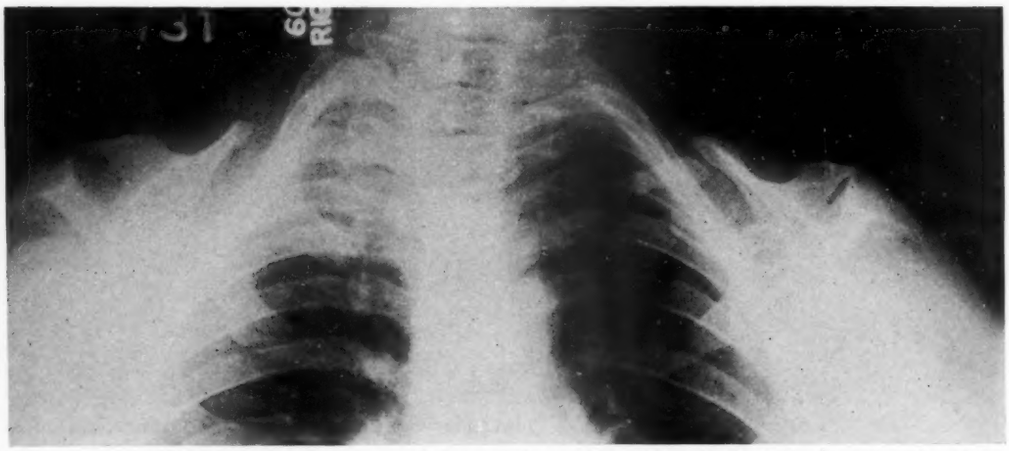

FIG. 3. Case II. X-ray showing a bony defect of the middle third of the left clavicle. The right clavicle has been resected.

CASE II. S. B., a forty-seven year old white woman, had first noted pain, numbness, tingling and weakness in the left hand and arm five years prior to admission. At that time she had been studied at another hospital and conservative therapy recommended. The symptoms had improved during the following seven months. Five months prior to admission similar symptoms occurred for the first time in the right arm.

Examination revealed an absence of all major arterial pulsations in both arms. The hands were not cold and there was no pallor. Oscillometric studies showed no pulsations in the arm or forearm. There was a palpable defect in the middle third of both clavicles. X-ray examination of the clavicles revealed a congenital absence of the middle third of the bone bilaterally. (Fig. 3.)

On July 19 and August 2, 1950, subtotal resections of the medial and lateral fragments of both clavicles including the periosteum, anterior scalenotomy and mobilization of the subclavian artery were performed. The subclavian artery was found to be thrombosed on both sides. The tip of the lateral segment of the clavicle pressed upon the subclavian arteries bilaterally.

Postoperatively the symptoms in the right arm cleared within a week. At one time feeble radial pulsations were felt bilaterally by a number of observers. At the time of discharge patient was asymptomatic. She was followed up by her family physician in Venezuela for eighteen months and remained in good health with normal use of the upper extremities.

This unusual clavicular anomaly illustrates the occurrence of vascular thrombosis in an artery long subjected to minimal degrees of trauma. We are unaware of a similar case in the literature. It is apparent that the rich collateral anastomosis around the shoulder prevented severe ischemic sequelae in the extremities.

FUNCTIONAL ABNORMALITIES

In addition to those clavicular anatomic abnormalities already enumerated, there may be clavicular injury to the subclavian vessels as a result of compression of these structures between the clavicle and the first rib. The syndromes to which we refer are the costoclavicular and the hyperabduction syndromes. These conditions are specific entities in a larger classification which has been loosely termed the "shoulder girdle" syndrome and which also includes the cervical rib and scalenus anticus syndromes.

The costoclavicular syndrome was described by Falconer and Weddell[6] in 1943 and was believed to result from narrowing of the interval between the clavicle and the first rib when the shoulders were depressed backward and downward. As a result of this narrowing the neurovascular structures situated in the retroclavicular region were pinched between the clavicle and the first rib. In 1945 Wright[7] described a syndrome of upper extremity neurovascular aberration which resulted from hyperabduction of the arms with the elbows flexed. The symptoms were noted in individuals who slept in the position of hyperabduction and individuals whose occupational habits included prolonged periods of hyperabduction. Wright believed that hyperabduction produced compression and pinching of the subclavian vessels and nerves between the clavicle and the first rib. A further site of neurovascular compression in the position of hyperabduction

was thought to be the point at which the vessels and nerves passed beneath the tendon of the pectoralis minor and under the coracoid process.

The diagnosis of clavicular compression of the neurovascular structures against the first rib may be suspected from the history of symptoms referable to the subclavian vessels and the brachial plexus following the assumption of specific positions. The costoclavicular syndrome is characterized by symptoms when the shoulders are maintained in a downward and backward position as best exemplified by the knapsack-carrying soldier in whom Falconer and Weddell originally described the syndrome. Hyperabduction symptoms may be noted upon arising in the morning after the patient has maintained this not uncommon sleeping position for many hours, or may appear during the course of a working day in which the subject is required to hyperabduct his arms repeatedly. Illustrations of this occupational type include telephone operators and grease pit mechanics. Certain simple physical tests are of value in confirming the diagnosis of the costoclavicular and hyperabduction syndromes, the most important of which is the observation of the disappearance of palpable arterial pulses in the affected extremity upon assumption of the symptom-producing position. Depression of the patient's shoulders downward and backward will produce marked dampening of the radial pulse if the etiology is costoclavicular in origin. Correspondingly, hyperabduction produces diminution in the pulse with abduction of the arm. The point of obliteration may range from 45 to 180 degrees. Palpatory observations should be confirmed by oscillometric determinations at the wrist while the various maneuvers are performed. One should also test for the cervical rib and scalenus anticus syndromes by having the patient turn his head toward the unaffected side and inspire deeply with the arm adducted. These syndromes will also produce diminution or complete obliteration of the palpable and oscillometric pulsations. An x-ray for cervical rib should be included in any evaluation of these patients; and should venous occlusion appear to be present, venous pressure and a venogram are routinely done. It is important to correlate changes in pulse and oscillometric volume with the patient's symptomatology, for it has been noted that obliteration of the radial pulse may be produced by these maneuvers in a significant portion of the population. Wright has stated that the hyperabduction maneuver resulted in the obliteration of the pulse in 83 per cent of a series of 150 young men. Therefore, it is evident that one must establish a cause and effect relationship between posture and physical findings. Furthermore, abandonment of the symptom-producing posture should result in relief of symptoms. Finally, consideration should be given to other conditions which may resemble that of the shoulder girdle syndrome. These include coronary insufficiency, primary vascular disease of the upper extremity (i.e., Raynaud's disease, arteriosclerotic thrombosis of subclavian artery, thrombosis of subclavian vein, thromboangiitis obliterans), orthopedic disorders of the shoulder and cervical spine, and neurologic abnormalities of the cervical spinal cord.

Conservatism is the keystone of therapy in the treatment of the syndromes resulting from functional compression of the retroclavicular neurovascular structures. Emphasis should be placed upon avoiding those postures which produce neurovascular compression. In those instances where occupational activities result in repeated and prolonged assumption of the offending position, a change is recommended. However, when simpler measures do not afford relief, and in those cases in which thrombosis of the subclavian artery or vein supervenes, operative therapy is in order.

Case III. J. R., a thirty-three year old white man, was first seen in March, 1950, at which time he complained of aching and numbness in both hands for the preceding three years. The patient had been employed as a polisher on an automobile assembly line and his work required him to hold a 35 pound buffing machine at arms' length at an angle of 130 degrees for prolonged periods. The symptoms disappeared when the arms were brought to the side but recurred when he resumed work. For one year preceding admission he had noted numbness and pain in his hands when sleeping with his arms over his head.

Physical examination was essentially negative. The hands were warm and no trophic changes were present. The radial and ulnar arteries were palpable bilaterally. However, abduction of the arms to 90 degrees resulted in obliteration of the radial pulses. This phenomenon was observed in the sitting or supine position and was confirmed by oscillometric studies. Depression of the shoulders downward and backward also produced obliter-

ation of the radial pulse with an absence of oscillometric pulsations in the wrist.

The patient was thought to have a mixed hyperabduction and costoclavicular syndrome. In view of the fact that there was no evidence of significant subclavian vascular injury, conservative measures including a change of occupation were recommended. The patient returned in ten months with essentially unchanged symptoms. In the interim he had worked as an oil sander which had involved using his arms in all positions but had not required the lifting of heavy objects. The physical findings were the same and the radial pulse could be easily obliterated with abduction of the arms to 90 degrees or performance of the costoclavicular maneuver. In view of the failure of response to conservative therapy, operation was advised. On March 1, 1951, a left partial claviculectomy with division of the scalenus anticus muscle and mobilization of the subclavian artery was performed. A similar procedure was performed on the right side eight days later. At both operations it was observed that the subclavian artery was undergoing repetitive compression between the clavicle and the first rib when the arm was abducted or the shoulders depressed. One week following the second operation both arms could be abducted to 180 degrees without dampening of the radial pulse. Oscillometric readings confirmed this finding:

Wrist at	Preoperatively		Postoperatively	
	Rt.	Lt.	Rt.	Lt.
0°	1.8	2.0	4.5	4.5
90°	0.2	0.0	4.5	4.5
135°	0.0	0.0	4.5	4.0
180°	0.0	0.0	3.5	3.5

The patient was discharged from the hospital but returned in three months complaining of pinching in the operative region when lifting heavy objects or leaning forward to tie his shoes. X-rays of the operative regions revealed bony regeneration in the region of the previously resected clavicular segments. The regenerated areas of clavicle and adjacent periosteum were excised with relief of symptoms.

This case illustrates a combined syndrome (i.e., hyperabduction and costoclavicular) which is not uncommon in the functional shoulder girdle syndromes. In a series of fifteen cases of shoulder girdle syndrome treated by us, four have presented combined syndromes. Beyer and Wright[8] have also stated that symptoms attributable to more than one mechanism are often present. Finally, as previously emphasized by one of us (J. W. L., Jr.), the periosteum of the clavicle must be removed at the time of claviculectomy if troublesome regeneration or callus formation is to be avoided.[9]

The final case to be presented is one of subclavian vein thrombosis secondary to the hyperabduction syndrome which we have treated by section of the pectoralis minor tendon. Beyer and Wright have called attention to the fact that two mechanisms appear to play a role in production of symptoms in the hyperabduction state. These authors illustrated in their paper the compression of the subclavian vessels as they pass beneath the pectoralis minor tendon and under the coracoid process. It has been our impression that in certain cases this may represent the major site of compression rather than compression between the clavicle and the first rib. Furthermore, Cooper[10] informed us that he had performed section of the pectoralis minor tendon in three cases of the hyperabduction syndrome with gratifying results. Accordingly, we have utilized this procedure in four patients with marked benefit in three.[11] The remaining patient was unimproved, and it is our impression that claviculectomy will be necessary to alleviate his symptoms.

Case IV. C. S., a thirty-nine year old white woman, was first seen by us in August, 1953, with a history of redness, swelling and paresthesias of the right arm. Excessive use of the extremity seemed to increase the swelling and discoloration. She had noted rapid and extreme fatigue of the entire right arm when performing such tasks as combing her hair. She had consulted a surgeon in June who reported moderate erythema of the right arm and forearm, and non-pitting edema of the right arm. The right arm was found to have a 1 inch greater circumferential diameter than the left. Oscillometry revealed slightly diminished pulsations in both arms. The blood pressure was 140/90 in the right arm and 130/90 in the left arm. X-rays of the chest and cervical spine were negative. Anterior scalenotomy had been performed in June, 1953, without relief of symptoms.

When seen in August the right arm and forearm were respectively 3 and 2 cm. greater in size than the left. There was moderate cyanosis of the right arm. The scalenus anticus and costoclavicular maneuvers were negative. However, the hyperabduction maneuver produced obliteration of the radial pulse at 90 degrees. It was believed that the patient had a thrombosis of the subclavian

vein and a hyperabduction syndrome with intermittent occlusion of the subclavian artery. Section of the tendon of the pectoralis minor muscle was performed on November 6, 1953. When seen one month postoperatively the patient reported that paresthesias and redness had disappeared. The right radial pulse remained palpable at 180 degrees of hyperabduction. The right arm and forearm measured 2½ and 1½ cm. greater in diameter than the left, a decrease of ½ cm. from the preoperative measurement. The patient has continued to be asymptomatic although slight residual swelling secondary to the subclavian vein thrombosis persisted when examined eleven months postoperatively.

SUMMARY

Clavicular injury to the subclavian artery and vein may result from a variety of syndromes. Acute injury is uncommon and the trauma is usually of a more subtle and chronic type. The injury may result from anatomic derangements following malunion of a clavicular fracture or from congenital malformation of the clavicle. However, functional vascular injury is more commonly observed and is illustrated by the costoclavicular and hyperabduction syndromes. It is important that these syndromes be recognized and appropriate operative measures utilized if the distressing symptoms of subclavian vein or artery thrombosis are to be prevented.

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Traumatic Avulsion of the Bladder Neck and Prostate Complicating Fractures of the Pelvis*

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A REVIEW of the recent statistics concerning trauma to the lower urinary tract occurring as a complication of fracture of the pelvis is interesting. One cannot but be impressed with the fact that although there has been a decrease in the reported mortalities, the sequelae arising as an aftermath of such trauma are still appallingly high. I wish to call special attention to those lesions of the lower urinary tract which are frequently associated with lateral crushing injuries to the bony pelvis. These fractures are caused typically by trauma so violent as to disrupt the continuity of the pelvic architecture. (Fig. 1.) They are commonly complicated by a complete severance of the urethra, usually at the level of the apex of the prostate, producing an avulsion of the bladder neck and prostate. This is a most serious occurrence since experience has shown us that failure to correct the anatomic deformity of the urinary tract resulting from the injury, either because of incomplete, improper or delayed treatment, leads to an irreparable lesion which forever incapacitates the patient. It is with the hope of aiding in the care of these unfortunate individuals and eradicating the pitfalls in the treatment that I wish to crystallize my experience in their management.

FIG. 1. Severe disruption of the pelvic architecture produced by a lateral crushing injury. This may result in separation of the symphysis, fracture of the pubic rami and/or complete fracture dislocation of the pelvic girdle, and is often accompanied by an avulsion of the bladder neck and prostate.

MECHANISM

The mechanism for the production of an avulsion of the bladder neck and prostate is not difficult to understand when one considers the anatomy of the vesicourethral junction and its vulnerability in the face of such violent trauma. (Fig. 2.) Anatomically,[11] the membranous urethra is fixed by virtue of the superior or inferior portions of the fascia of the urogenital diaphragm. It is anchored anteriorly to the pubis, and posteriorly to the ischial ramus and tuberosity and the lower edge of the sacrotuberous ligament. As it passes through the rigid body of the triangular ligament, the membranous urethra is bound to it by loose connective tissue and has a small degree of mobility. The apex of the prostate on the other hand, is not bound to the triangular ligament by any strong fibrous structure. As a consequence, the urethra in this region is unprotected. With crushing injuries in which there is a disruption of the pelvic architecture and sudden displacement of the triangular ligament,

* Aided by a grant from the Simon Holland and Son Research Foundation.

the membranous urethra is stretched and drawn out into an unsupporting tube, and rupture occurs at the most vulnerable and weakest point which is the apex of the prostate. This type of rupture, which is usually of the complete variety, is therefore almost always produced by a severance of the prostatic and membranous urethra through a scissors-like action resulting from a tearing of the fascia of the urogenital diaphragm and/or strain on the ligamentous moorings of the bladder and urethra. It is rarely due to actual shearing by bony fragments. During this process of severance, the puboprostatic ligaments are torn. In addition to the urinary extravasation, there is the added factor of pelvic extraperitoneal hemorrhage initiated by the pelvic fracture. In close proximity to the anterior position of the pelvic girdle are a number of blood vessels which may be easily traumatized. Trauma to the muscles attached to the pelvis may also contribute to the extravesical bleeding.

The loss of the puboprostatic ligaments and the pressure of the extravasated blood and/or urine in the space of Retzius causes the neck of the bladder with the prostate to be pushed upward and backward, producing a posterior dislocation of the prostate and the vesical neck. (Fig. 3.)

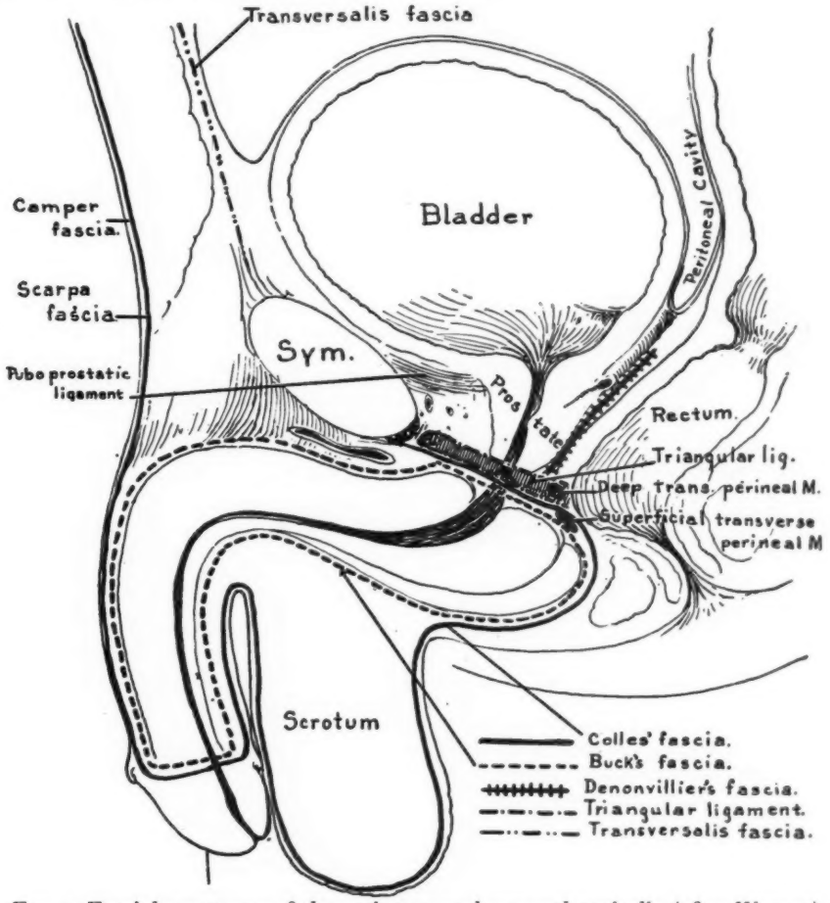

FIG. 2. Fascial structures of the perineum and external genitalia (after Wesson).

PRINCIPLES OF TREATMENT

A knowledge of the distorted anatomy and the existing pathology has helped us to understand that the following must be done without delay if we are to treat this condition successfully: (1) establishment of adequate urinary diversion; (2) re-establishment of normal alignment and contour of the injured urethra; and (3) prevention of undue elongation and tortuosity of the posterior urethra.

1. *Establishment of Adequate Urinary Diversion.* A cumulative literature on the subject has demonstrated unequivocally that diversion of the urine by suprapubic cystostomy has been of paramount importance in lessening the mortality and morbidity associated with rupture

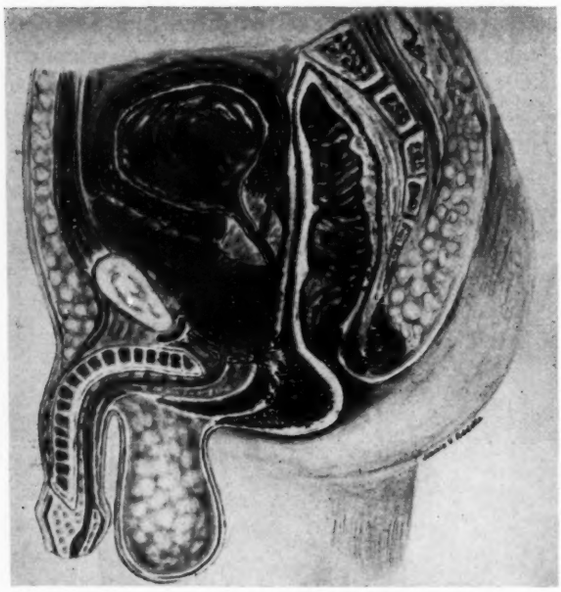

FIG. 3. Sagittal section showing bladder and prostate separated as a unit from the urethra by laceration of its membranous portion and the urogenital diaphragm. Note the posterior dislocation of the vesical neck and prostate. Also note the retrovesical and prevesical hematoma and extravasation. This represents the findings at operation in six of our cases.

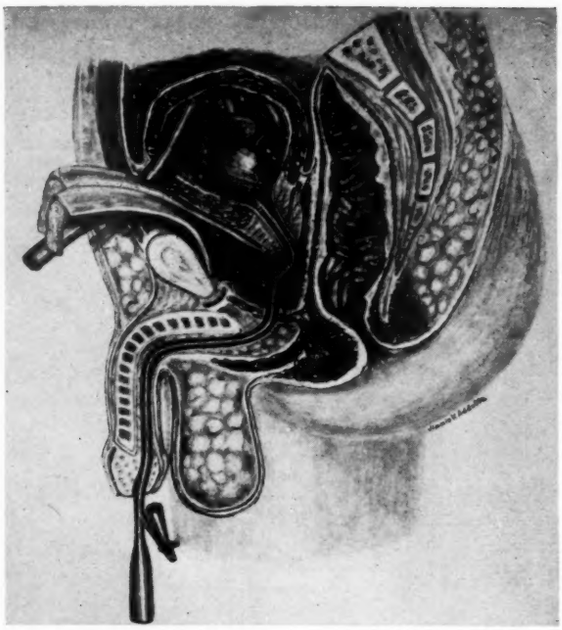

FIG. 4. This picture illustrates the necessity for traction in this type of injury. Even if at the time of the suprapubic cystotomy a Foley catheter is inserted through the urethra into the bladder, epithelization and canalization of the intervening gap cannot occur. It will be filled in by fibrous tissue and a massive stricture will result. If the condition of backward displacement of the vesical neck and prostate is not rectified at the initial operation, secondary procedures will of necessity have to be undertaken at a later date. These are usually unsuccessful.

of the lower urinary tract. As a means of urinary diversion this method has been shown to be the safest and most ideal technic of placing the bladder and urethra at rest and of preventing further extravasation. Recently, however, with the advent and widespread use of the newer antibiotics, there has been a tendency on the part of some surgeons to do away with suprapubic diversion of the urine in the management of avulsion of the bladder neck and prostate. Following the insertion of a Foley catheter and application of the necessary traction for correction of the vesical neck deformity, these men have closed the bladder tightly by primary suture. I cannot ascribe to this technic under any circumstances. I believe that it is extremely hazardous even if an occasional patient treated with primary closure is shown to have had a good end result. Dependence on catheter drainage alone and failure to provide for an adequate and efficient safety valve if complications arise is fundamentally contrary to the basic principles involved in the management of this most serious lesion. I cannot reiterate too strongly that suprapubic cystostomy must be performed in all cases and that it is as important in the management of these cases as definitive correction of the avulsion itself.

2. *Re-establishment of Normal Alignment and Contour of the Injured Urethra.* Rupture at the apex of the prostate results in a severance of the prostatic from the membranous urethra for distances varying from a few millimeters to several inches, usually the latter. If the restoration of the channel is unduly delayed through negligence or misjudgment, the urethral ends will be retracted, possibly occluded. Epithelization and canalization of the intervening gap cannot conceivably occur. It will be filled in by fibrous tissue and a massive stricture will result. Even if at the time of the suprapubic cystotomy a catheter is inserted through the urethra into the bladder and retained for a long time, the wide area of defect cannot be bridged over with normal mucosa. Retraction of the prostatic from the membranous urethra will inevitably occur, producing a severe stricture, sinus formation and a distorted and displaced neck of the bladder. If the condition of backward displacement of the vesical neck and prostate is not rectified at the initial operation, secondary

procedures will of necessity have to be undertaken at a later date. These will require extensive perineal dissection, excision of scar, drainage of infected areas and an attempt at restoration of alignment of the urethra. This has proved to be most difficult and well nigh impossible. (Fig. 4.)

Normal alignment and contour of the injured urethra is obtained only by correcting the backward displacement of the vesical neck and prostate before they are anchored in an abnormal position. The base of the bladder must be brought down to its normal position and the severed ends of the urethra must be in direct contact and normal alignment for a satisfactory end result.

Perineal exposure and direct primary suture of the avulsed urethra or bladder neck would seem to be an ideal procedure under ordinary circumstances. Experience has shown that it is impractical, time-consuming and contraindicated under the circumstances of a severe disruption of the pelvic architecture. Few general surgeons have had the necessary experience to perform a primary perineal urethrovesical repair. Even if one has the ability to do so, the likelihood of success in suturing the contused ends of the avulsed urethra and/or neck of the bladder in a hemorrhagic infected area is quite doubtful. In addition, the marked shock which is usually present is made worse by putting the patient up in lithotomy position. The latter exaggerates the fracture, further retracts the severed ends of the urethra and distorts the normal alignment of the canal.

The severed ends of the urethra and the neck of the bladder and prostate can be brought down into approximation with the triangular ligament by the simple expedient of external traction applied either through silk sutures at the apex of the prostate or through an indwelling urethral catheter or both, until the bladder neck is firmly anchored in its anatomically correct position. This has proved to be the simplest and least traumatic of all procedures for this condition. End results as previously reported by Rexford, Mason and Ratliff, Simpson-Smith,[9] Reynolds,[8] and Ormond and Fairey[7] have been excellent.

3. *Prevention of Undue Elongation of the Posterior Urethra.* Undue elongation and tortuosity of the posterior urethra is usually a sequel to inadequate drainage of the extravasated blood and urine in the most dependent portions of the pelvis. The extravasation in the lateral and posterior confines of the pelvis may be adequately drained by multiple drains inserted at the time of the suprapubic cystotomy. Extravasation deep in the pelvis and especially in the region of the triangular ligament cannot possibly "drain uphill" even if drains are inserted from above to these areas. The blood and urine in the dependent area readily become infected; with suppuration, the infection may break through to the perineal or perirectal areas. In the healing process, even with proper alignment of the vesical neck and urethra, periurethral fibrosis may result in distortion and elongation of the prostatic and membranous urethra and in stricture formation. Routine drainage of this area by means of a small soft rubber tube exiting to the perineum adequately and satisfactorily takes care of this eventuality.

MANAGEMENT OF AVULSION OF BLADDER NECK AND PROSTATE

Experience in traumatic surgery has taught us that the following statements must be accepted as the gospel truth if we are to treat the severely injured patient successfully.[6]

1. In the management of the patient with multiple severe injuries the treatment of the individual as a whole is of prime importance.

2. The patient should be admitted to the surgical service rather than the orthopedic division even though the patient has sustained a fractured pelvis or other bony injuries.

3. The responsibility for the continuity of this patient's over-all care should be invested in one and only one individual. The latter should be one of the general surgeons who directs a group of physicians, among them a urologist.

4. The urologist should perform the necessary urologic studies only after the over-all condition of the patient has been improved.

5. Complete urologic study and a planned routine are essential for an early and accurate diagnosis. This is of paramount importance if we hope to shorten the time interval from injury to operation and to institute rational treatment in time for it to be of real value.

Diagnosis. There is no characteristic clinical picture for avulsion of the bladder neck and prostate.[6] The presence of shock, the inability to void, the show of blood at the external meatus and the difficulty of catheterizing these

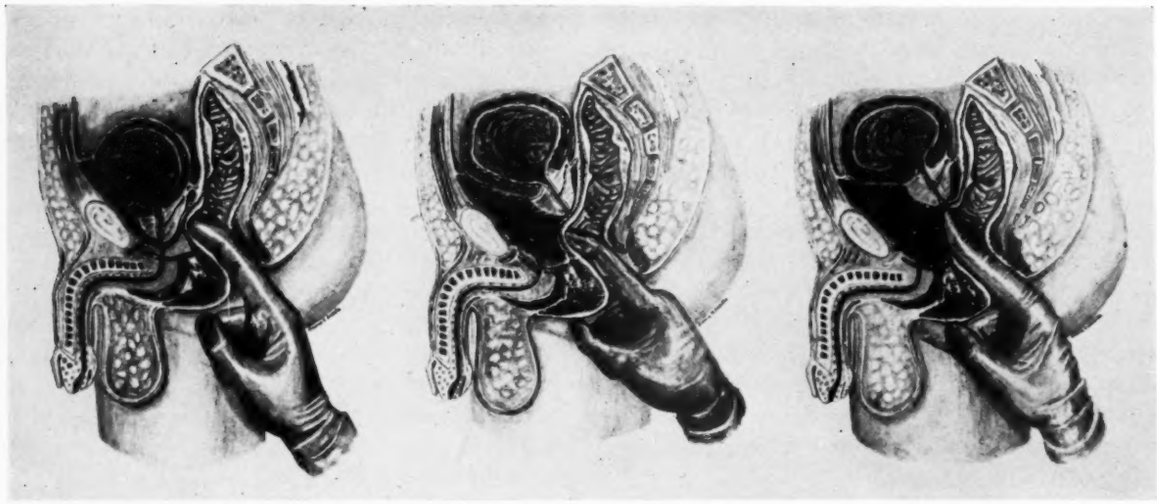

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FIG. 5. Illustrates how a diagnosis of avulsion of the bladder neck and prostate can be immediately established by rectal palpation. A, in uncomplicated extraperitoneal rupture the membranous urethra can be palpated as a longitudinal cord between the anal sphincter and the apex of the prostate; the latter is in a normal position and is not mobile. B and C, in avulsion the rectal finger feels only a soft mass of blood where the prostate should be. The prostate here is exceedingly mobile and higher than normal.

patients are all highly suggestive of a rupture of some portion of the lower urinary tract. Their presence is not conclusive of an avulsion. Conversely, the lack of any or all of these criteria is not indicative of the absence of an avulsion of the bladder neck and prostate. Urologic roentgen studies which may be done at the bedside as previously described by the author,[5] if time and condition of the patient permit, may under ideal conditions establish the diagnosis of a rupture of the bladder or urethra or both. Based on roentgenologic interpretation, a differential diagnosis between rupture of the bladder with extraperitoneal extravasation, rupture of the urethra with extravasation and avulsion at the neck may be most difficult.

Despite the foregoing, the diagnosis of avulsion of the bladder neck and prostate should be relatively simple if one keeps the possibility of its occurrence in mind.[8,10] Experience in the diagnosis of this condition has taught me that the existence of this lesion should always be considered as being present until proved otherwise in patients who, as a result of violent trauma, have sustained severe disruption of the pelvic architecture. Especially important are the lateral crushing injuries producing a separation of the symphysis, fracture of the pubic rami and/or complete fracture dislocation of the pelvic girdle. In this regard I have found that rectal palpation is one of the most important steps in the physical survey of patients who have sustained the aforementioned type of bony injury. The recognition of the existence of an avulsion of the bladder neck and prostate can be established immediately without recourse to any other procedures. Ordinarily, the membranous urethra can be palpated as a longitudinal cord between the anal sphincter and the apex of the prostate as it lies against the symphysis pubis. If the membranous urethra is ruptured, the fossa on either side of the membranous urethra is obliterated and the prostatic apex is dislocated. In complete rupture the rectal finger feels only a soft mass of blood where the prostate should be. The prostate here is exceedingly mobile and higher than normal. This finding indicates that the prostate and bladder neck are disrupted from the membranous urethra. In each one of our six cases in which the prostate was found to be exceedingly mobile and the apex pushed up, a complete tear of the urethra was found at operation. In three other cases, each with a rupture of the posterior urethra, in which the rectal examination disclosed that the prostate was not dislodged, the urethra was not completely severed and avulsion was not present at operation. (Fig. 5.)

Management of a Case. A review of my first three cases of avulsion of the bladder neck and prostate revealed that the end result was not

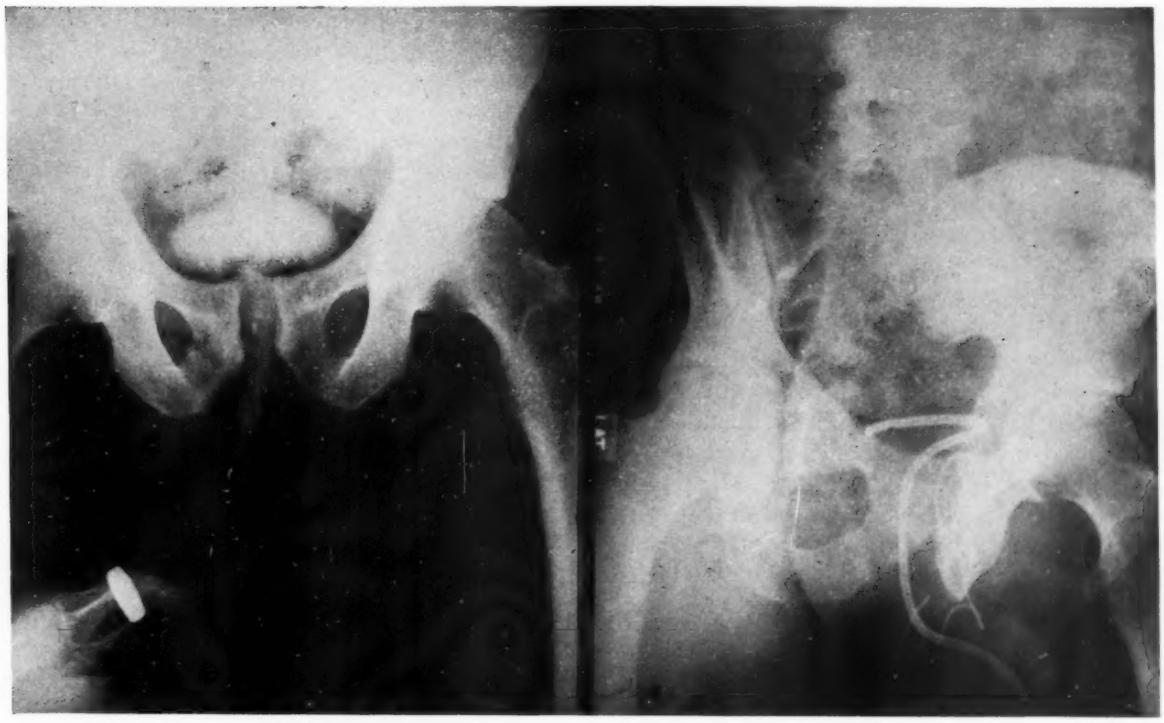

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FIG. 6. The complications resulting from inadequate drainage of the extravasated blood and urine in the most dependent parts of the pelvis are illustrated in this case. At the time of the original operation multiple drains were inserted suprapubically to take care of the extravasated fluid. No perineal drain was used. This resulted in: A, difficulty in voiding due to stricturing of the prostatic urethra and marked elevation of the inferior sphincteric lip of the vesical neck. B, multiple perineal sinuses draining purulent material. (This is a lateral film in which a catheter has been passed to the bladder and the sinus tracts injected with lipiodol.) Treatment in this case was by dilatation of the urethra, transurethral resection of the vesical neck and perineal excision of the sinus tracts.

as satisfactory as commonly reported in the literature. Although, anatomically, alignment of the vesical neck and urethra appeared to be excellent in all, none were free of complications in the immediate postoperative period or of late sequelae. Two patients had a morbid course because of persistent and prolonged suppuration. In two accidental breakage of the Foley bag in the first few days led to a release of traction, necessitating a reopening of the wound, reinsertion of a new Foley catheter and reapplication of traction. Although each of the three patients tolerated the traction apparatus well, considerable difficulty was experienced in keeping the mechanism free of entanglement with the bedclothes and of thus maintaining an adequate traction force at all times. Stricture of varying degree at the vesical neck requiring continued dilatation was encountered in all as late sequelae. In one, in addition, because of purulent urethritis, multiple urethral strictures developed which were anterior as well as posterior. One patient, a child, had to be subjected several months later to cystolithotomy because of the development of a large bladder calculus. Another patient, because of persistent purulent drainage in the perineum, required perineal section with excision of the multiple sinus tracts. (Fig. 6.) Each of these three patients had persistent urinary tract infection which was resistant to antibiotics for many months. In one, persistent pyuria has remained despite the absence of any urologic pathologic condition.

It became readily apparent to me that no other form of urologic trauma required as much meticulous attention to fine detail as the management of avulsion of the bladder neck and prostate. Desirous of avoiding some of the pitfalls in the management and hopeful that the end result could be satisfactory from an anatomic standpoint, free of sequelae and stricture, I formulated a routine plan of treatment. Although I recognize the fact that no absolute rule of thumb should be followed in the management of any injury, an orderly standardized

method, whenever possible, is far superior to a haphazard approach or none at all. I have now followed this routine in three successive cases and have found it to be simple, safe and eminently satisfactory. The rationale for its institution and the reasons for its continued use are given in the discussion which follows.

Immediate Operation

1. The diagnosis of avulsion of the bladder neck and prostate having been established, the patient should be operated upon without delay. If the general picture is one of severe shock, blood and/or plasma expanders should be administered until improvement satisfactory for operative intervention is obtained. The patient should be transferred from his bed to the operating table on a Bradford frame or on a sling as carefully as possible in order not to increase the shock. Inhalation anesthesia is preferred. Spinal anesthesia is contraindicated because the patient is bordering on or is in shock.

2. Ideal exposure is obtained by a midline incision extending from 1 inch above the symphysis to just below the umbilicus. This incision is carried down through the rectus sheath following which the rectus muscles are retracted.

3. The prevesical space and the perivesical areas are then aspirated and mopped out as much as possible so that one may identify the superior aspect of the bladder with its peritoneal reflection.

4. At this point the abdominal cavity should be inspected to rule out a possible associated intraperitoneal injury. This is best accomplished by incising the peritoneum just above its attachment to the superior aspect of the bladder. The opening need not be large. Rapid inspection will determine if there is free blood and/or urine in the peritoneal cavity. If none is found, the opening in the peritoneum is promptly closed. On the other hand, if free fluid is found, the opening in the peritoneum is widened by continuing the incision upward. Inspection and correction of any intra-abdominal pathologic condition is then undertaken, following which the peritoneal cavity is closed without drainage. This step is important. In one of our cases an associated rupture of the mesentery was found by exploring the abdomen. Evidence for this was completely masked preoperatively by the severe fracture of the pelvis and the avulsed bladder neck.

5. Cystotomy is then performed. The bladder is grasped and opened below the peritoneal reflection. The incision is continued downward for a distance of 2 to 3 inches and the bladder completely emptied by aspiration.

6. A Foley catheter must now be introduced into the bladder. If, as may rarely occur, a catheter has been introduced into the bladder at the time of the initial examination, it should be left *in situ* until the bladder has been opened. With avulsion of the bladder neck and prostate it is usually impossible to pass a catheter per urethra, either prior to operation or at the time of the suprapubic cystotomy. Many ingenious methods have been described to circumvent this difficulty.[7] Bank's method is by far the best devised. I have always found it to be simple of execution and most satisfactory. Two metal F 18 urethral sounds are used. One is passed suprapubically through the opened bladder and through the vesical neck to the seat of the rupture. The other sound is passed through the external meatus of the penis until it is in contact with the first sound. These two sounds are held one in each hand and manipulated until their beaks touch end to end. By slowly withdrawing the bladder sound and pushing the urethral sound inward, keeping their ends in contact at all times, it is quite simple to guide the urethral sound past the point of rupture and into the bladder. An F 16 coudé catheter is then fastened snugly to the sound in the bladder by forcing the open end of the catheter onto the tip of the sound. By gradual withdrawal of this sound with the coudé catheter firmly attached to it, the latter is thus passed in a retrograde manner along the course of the urethra; the open end of the catheter is thus at the external meatus and its other end is in the bladder. The closed tip of a 30 cc. Foley catheter is then forced into the open end of the coudé catheter and held firm with a silk suture. By grasping and pulling the closed end of the coudé catheter out of the bladder, the Foley catheter may then be guided into the bladder. The silk suture by which the Foley catheter is anchored to the coudé catheter is cut and the latter removed. Following this, the bag at the end of the Foley catheter is inflated to capacity.

7. A long heavy silk suture is then sewn to the tip of the Foley catheter and brought out through the opened bladder to be tied later to a tongue depressor on the abdominal wall.

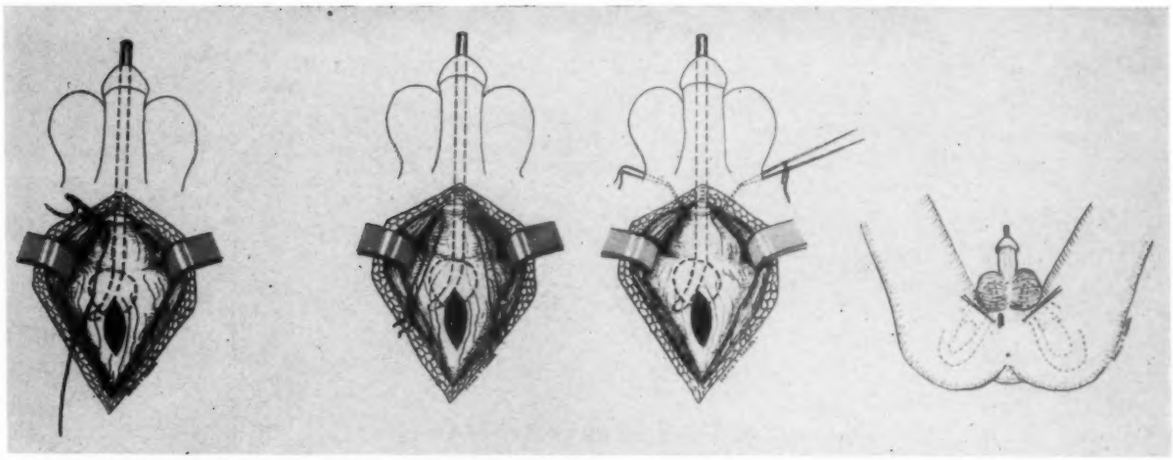


FIG. 7. This illustrates the technic by which silk traction sutures are passed from the apex of the prostate to the perineum. This produces a more anatomic method of alignment and, together with the technic of aiding traction by attaching the catheter to the knee, a more rational, certain and efficient method of correction of the bladder neck deformity.

This step is of vital importance in the reinsertion of a new Foley catheter if the one *in situ* should break or in the changing of catheters by the "railroad method" as will be described later.

8. Before bringing the severed bladder neck and prostate down into approximation with the triangular ligament, drainage of the dependent area of the pelvis should be taken care of. Blunt dissection is carried out in an area approximately at the lateral aspect of where the restored avulsed prostate will lie and it is continued down to the superior layer of the triangular ligament. A stab wound is then made through the triangular ligament and the perineum close to the base of the scrotum with a long Kelly clamp, and a small soft rubber tube is brought in for dependent drainage.

9. Two long traction sutures of heavy silk are placed through the substance of the prostate itself on either side of the midline at the apex. The four ends of these sutures are threaded on straight cutting needles. They are then passed behind the symphysis directly through the perineal tissues staying laterally and through the perineal skin behind the base of the scrotum, two on each side. With the vesical neck and prostate under direct vision at all times, the bladder neck and prostate are guided downward and forward so that it is in its anatomically correct position. While the displaced prostate is held in this location, the two silk sutures are tied on each side over a small rubber bolster. The tie is made as taut as necessary to obtain the most perfect anatomic alignment. (Fig. 7.) This was first suggested but never used by Leadbetter.[4]

10. Traction is further aided by tying the end of the Foley catheter to a rubber band around the knee just below the patella. The catheter should be fastened to this band on the lateral aspect of the knee. Should the patient flex his thigh, traction would be increased, whereas if the attachment around the knee is on the medial aspect, flexion would release the traction. A plastic spigot should be inserted into the open end of the catheter in order to prevent urine from draining through the catheter.

Steps 9 and 10 are most important in the surgical correction of avulsion. (Fig. 8.) As previously described, they represent a decided improvement and advantage over the technics formerly described in the literature. In order to obtain traction, the usual practice has been to attach a cord to the end of the Foley catheter. This cord is then carried over a pulley attached to a board at the foot of the bed. Satisfactory traction has been obtained by using 2 pounds of weight for the first forty-eight to seventy-two hours, and 1 pound thereafter for ten days to two weeks. While this has been reported in the literature as highly efficient, I have found that constant attention must be paid to the pulley system since the cord frequently becomes entangled in the bedclothes. This often results in an inadequate traction force being applied to the vesical neck deformity. In addition, if anything should

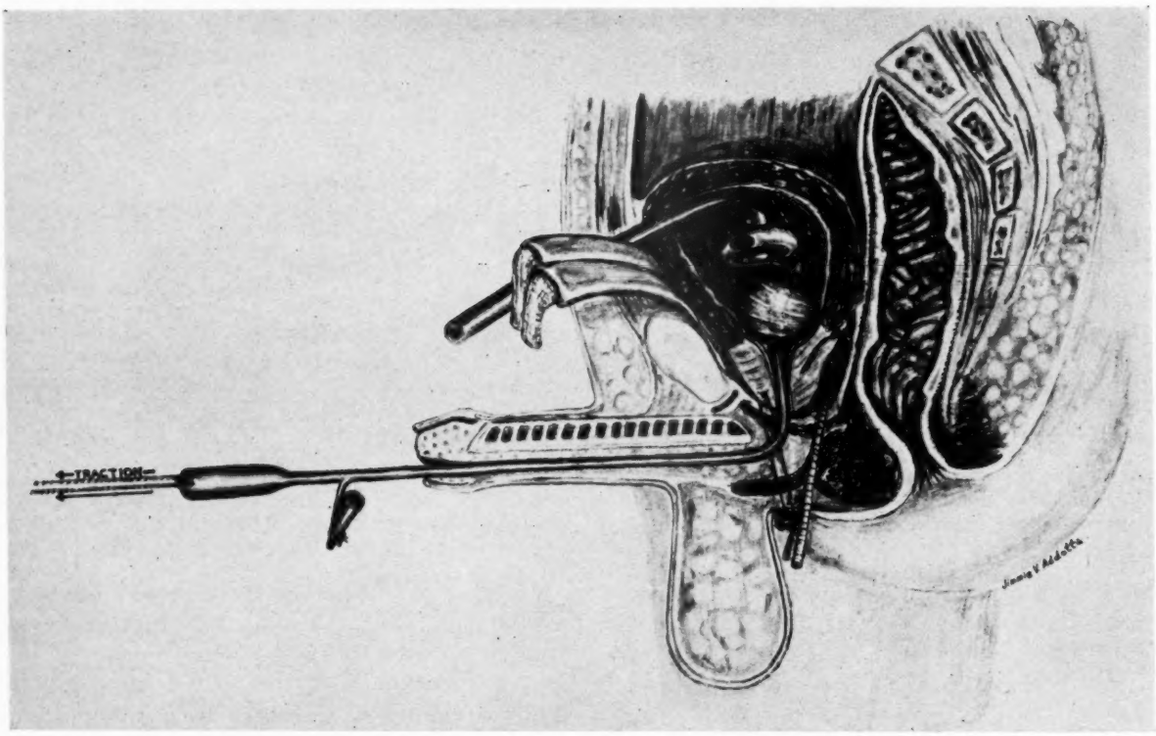


FIG. 8. Technic used by the author in the correction of avulsion of the bladder neck and prostate. Approximation of the vesical neck and urethra is obtained by traction mediated through a Foley catheter attached to the lateral aspect of the knee, and by silk sutures from the apex of the prostate to the perineum. Drainage of the extravasated blood and urine is obtained by multiple drains suprapubically, and by perineal drainage of the dependent areas of the pelvis.

occur to the traction mechanism neutralizing its effectiveness, considerable difficulty will ensue. I have had the misfortune in two cases of having the Foley bag break after several days of traction. This led to reseparation of the alignment of the bladder neck and urethra necessitating a reopening of the wound, insertion of a new catheter and reapplication of the traction. Traction sutures as used here prevents such an occurrence. In addition, its routine use produced a more anatomic method of alignment; and together with the technic of aiding traction by attaching the catheter to the knee, a more rational, certain and efficient method of correction of the bladder neck deformity is obtained.

11. Multiple drains are then placed around the bladder, one in the space of Retzius and one each on the lateral aspect of the bladder. The drains are left *in situ* until no further drainage is evident suprapubically. This usually occurs around the seventh to the tenth day postoperatively. A large suprapubic tube is then inserted into the bladder and the latter is closed around the suprapubic tube using interrupted chromic sutures. The silk suture tied to the end of the Foley catheter exits from the bladder alongside the suprapubic tube and is tied around a tongue depressor placed on the abdominal wall. If the Foley bag should break and the catheter is displaced downward into the urethra, the silk suture tied to the tip of the catheter forms a safety measure of the utmost importance. By sewing another catheter onto the Foley catheter and by pulling on the silk suture on the abdominal wall, another catheter can be inserted into the bladder by the "railroad method." This avoids the possibility of having to take the patient back to the operating room for reoperation and reinsertion of another catheter.

Postoperative Care

Surgical Care. It is outside the realm of this paper to discuss the management of the pelvic fracture. This may be left to the discretion of the surgeon in charge of the case.[3] Suffice it to say that whether immobilization of the pelvis is obtained on a Bradford frame, by a Russell type of traction applied to both legs or by

anterior and posterior body shells of plaster, no conflict or difficulty should result between the urologic and surgical management.

Urologic Care. 1. One of the causes of sepsis that may lead to stricture formation is the presence of urine over a raw area. This may invite necrosis. Despite suprapubic cystotomy which will divert the urine, and perineal and extravesical drains which will take care of the extravasated urine and/or blood, some urine will continue to trickle down alongside of a draining catheter. This urine exuding at the site of rupture may lead to local necrosis, periurethritis and stricture formation. This eventuality can be ameliorated to a great extent by tying off the end of the catheter. The indwelling catheter here should be used as a splint and not as a means of drainage in the immediate period after the injury. Further aids preventing leakage of urine at the site of the injury are high blocking of the foot of the bed and the use of the Stedman pump for suprapubic suction. Both of these should be continued for one week to ten days.

2. Traction obtained through the attachment of the Foley catheter to the lateral aspect of the knee is released after two weeks. The problem arises as to when one may safely dispense with the urethral catheter. A survey of the literature on avulsion of the bladder neck and prostate reveals that the catheter is being kept *in situ* for periods of four to eight weeks after these injuries. Considerable controversy, however, exists concerning the use of indwelling catheters in urethral ruptures. Posterior or bladder neck ruptures are said to tolerate indwelling catheters far better than bulbar ruptures; stricture has been thought to be less common with the former than the latter. Experience has shown that this is erroneous. In a large series reviewed by Simpson-Smith,[9] stricture was just as frequent in the posterior as in the bulbar tears. Since the urethral catheter formed the major treatment in over 80 per cent of the foregoing cases, one should seriously question the propriety of its use. The indweller may therefore very well be a cause of urethral stricture rather than a cure. It should be condemned on the grounds that even a normal urethra becomes septic with it in from three to four days. Ideally, no foreign body should come in contact with the urethral wound in its healing process.[2] I believe that although there are disadvantages to the use of an indwelling catheter, one has no other choice but to employ it in this type of injury. The catheter should be used in this event only as a splint and should be removed at the earliest possible moment.

3. A routine for determining when it is safe to dispense with the catheter follows (Fig. 9):[3] After the Foley catheter is released from the lateral aspect of the knee, its bag is deflated. Under sterile precautions, a silk suture is then sewn to the open end of the catheter at the external meatus. By gentle traction on the silk suture tied around the tongue depressor on the abdominal wall, the Foley catheter with its silk suture attached to it is pulled through the urethra into the bladder and out through the suprapubic wound. The Foley catheter is detached leaving the silk suture to traverse the urethra, one end lying free at the external meatus and the other end lying on the abdominal wall. The urethra is then filled with 8 per cent diodrast® solution and an x-ray taken at the bedside using the portable x-ray unit and the Lysholm grid. If there is extravasation of the contrast substance in the region of the vesical neck, complete healing has not as yet taken place and the catheter must be replaced. This is accomplished by sewing the meatal end of the suture to the tip of the new coudé catheter. Another silk suture is sewn to the open end of the catheter. Gentle traction on the silk suture lying on the abdomen directs the coudé catheter into the bladder while the silk suture fastened to its tip is brought out through the cystotomy opening and again tied around a tongue depressor. This procedure should be repeated at weekly intervals until a point is reached where one can discard the indwelling catheter based on the absence of extravasation. If, on the other hand, there is no extravasation of the contrast material, the catheter is not replaced. The silk suture is left *in situ* to traverse the entire urethra. During the next two weeks it will be of invaluable aid in dilating the urethra. This will be described later. Experience in the last three cases in which this technic was used revealed that complete healing had occurred after two weeks and that the urethral catheter did not have to be replaced in any of them. The perineal traction sutures are removed at the time that the urethral catheter is discarded.

Haphazard manipulation of the urethra should be guarded against. Since organisms can always be cultured from the anterior

urethra, this is a ready source of infection which can be forced back into the posterior urethra. Prior to any urethral manipulation, the glans penis should be washed with soap and water and the external meatus gently irrigated with aqueous zephiran.® All manipulation should be done under absolutely sterile conditions.

FIG. 9. A simple method for determining when the urethral catheter may be safely removed. Using the "railroad technic" the urethral catheter with a silk suture sewn to its end is drawn through the urethra into the bladder and out to the abdomen by gentle traction on the silk suture tied around a tongue depressor. The catheter is removed and the silk suture is left indwelling to traverse the entire urethra. A urethrogram is now taken. If there is extravasation of the dye, the catheter should be replaced. If, however, the urethra is shown to be intact, the catheter need not be reinserted. The silk suture is left indwelling in the urethra as an aid to dilatation of the urethra by the "railroad technic."

4. Following the removal of the urethral catheter, the suprapubic tube is gently irrigated twice daily with Suby's solution. Two weeks later, if the temperature is normal and if there is no further drainage of purulent material from around the suprapubic wound, the suprapubic tube is clamped for eight to ten hours and the patient given a trial at voiding. If he is able to do so satisfactorily, the suprapubic tube is removed. If he is unsuccessful, the tube is reopened and he is given another trial in one week.

If the patient is unable to void after several trials, the suprapubic tube is left *in situ*, being irrigated daily, until the patient is able to get out of bed. He is then given another trial. If he is still not able to urinate satisfactorily, observation cystoscopy followed by definitive surgery for a possible prostatic obstruction is undertaken.

5. The availability of the various antibiotics during the past ten years has greatly facilitated the management of lower urinary tract injuries. Because of the fact that we are dealing with acute lesions in very ill patients, the rationale has often been that it is justifiable, in the absence of a culture report, to prescribe routinely a combination of many antibiotics in the immediate postoperative period so as to offer the patient as wide an antibiotic protection as possible. The group of drugs most commonly being used in this regard is that of combiotic® and one or more of the broad spectrum antibiotics.

The aforementioned concept runs contrary to certain basic principles which have been established as a result of experience with the extraordinarily widespread use of these antibiotics. The most important and readily demonstrated outcome has been the selective elimination of the antibiotic-sensitive forms of many common pathogens and the emergence of resistant variants. Equally disturbing has been the development of intensely tetracyline-resistant organisms during the relatively brief period that oxytetracycline and chlortetracycline have been in clinical use. A second extremely important development has been the increasingly frequent occurrence of infections by organisms which were unknown a few years ago. The

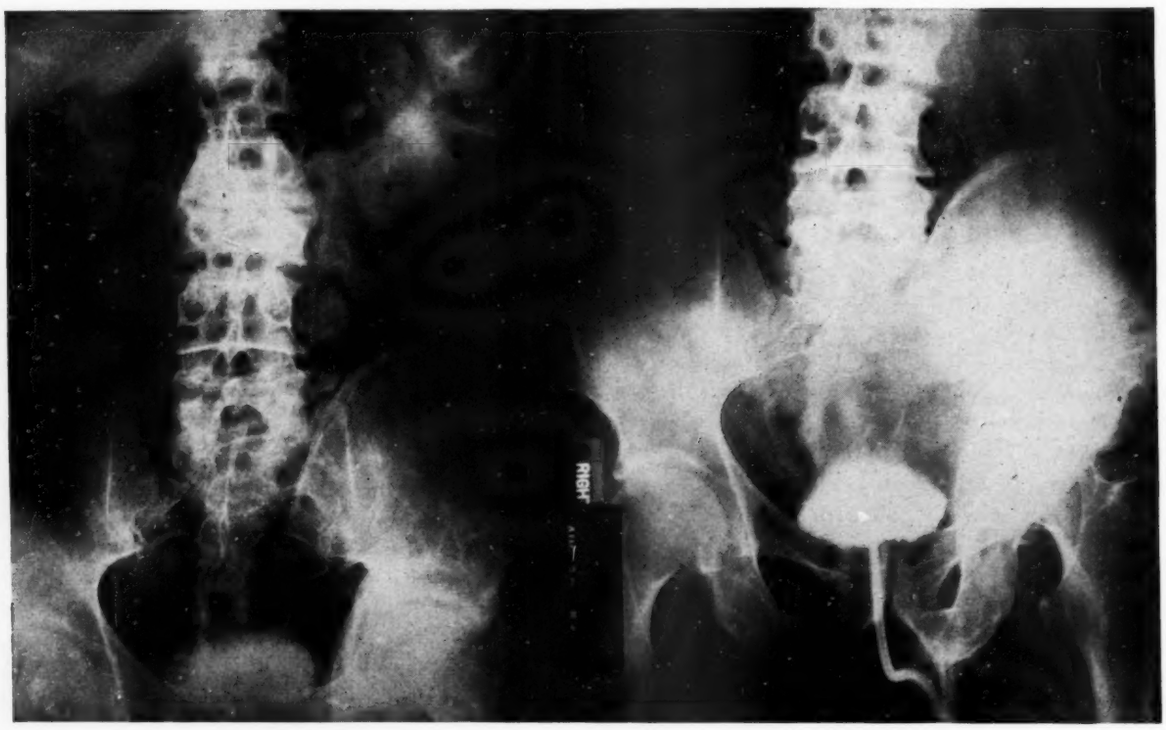
present clinical importance of the Aerobacter aerogenes and the pseudomonas group is outstanding. These organisms are generally intensely resistant to most or all of the available agents and are now common causes of persistent urinary tract infection, particularly in antibiotic-treated patients. A third and serious outgrowth of antimicrobial therapy has been the clinical problem of superinfection. This term denotes the appearance of an infection caused by an organism different from that which was responsible for the initial infection for which the patient was being treated. Recognition of such superinfection is of the greatest importance. It tends to occur particularly in the urinary tract and in certain specific situations such as the presence of drains, draining sinuses, foreign bodies, suprapubic tubes and/or indwelling catheters. Under such conditions the eradication of infection and the maintenance of sterile urine are impossible.

Experience has shown that if a diagnosis of rupture of the lower urinary tract is made early and the patient is immediately operated upon, there is very little extravasation of urine owing to the protective influence of sphincter spasm. Under such circumstances it would seem not only unnecessary but also unwise to administer antibiotics indiscriminately. If, however, the general condition of the patient is poor, if there has been an associated intraperitoneal lesion and/or if the bladder urine has been known to be infected prior to the injury, the administration of a large number of antibiotics might be justified until the general condition of the patient has become satisfactory. In this regard the antibiotics which are known to induce resistance rapidly should be discontinued as soon as feasible. Otherwise my immediate postoperative routine for the use of antibiotics is as follows: Crysticillin® 300,000 units twice daily, and gantrisin® 15 gr. four times daily are given for four to five days. At this time, the crysticillin may be discontinued unless a pulmonary condition complicates the course. The gantrisin is continued for a total of ten days. Mandelamine® three tablets four times a day is then given until all catheters and tubes have been removed and the patient is voiding satisfactorily. No attempt to sterilize the urine is made until this point is reached. At this stage a bacteriologic survey of the urine, including culture and sensitivity studies, is done. Appropriate antibiotics to which the known organisms are sensitive can then be administered in adequate dosage with the hope that the urinary tract infection may be successfully eradicated. After five to seven days of such therapy bacteriologic re-examination of the urine will inform us if the antibiotic should be changed or discontinued. If the infection is not eradicated within a reasonable time, urologic re-examination should be done to rule out the presence of calculus or residual urine which might well be a cause of the persistent infection. This plan has met with signal success in helping to avoid persistent urinary tract infections which have been a common sequel to such injuries.

We should rapidly become aware that we must discriminate in the use of antibiotics so that these valuable chemicals will not be used in needless prophylaxis or in the treatment of trivial concurrent infection, lest the time arise when they will not be available as life-saving agents in the patient who suddenly becomes seriously ill, or in the eradication of infection developing as a result of the injury.

The diet should be acid-ash in type, supplemented by large amounts of vitamins. Fluids should be forced so as to lessen the possibility of the formation of calculi in the recumbent position.

6. Following the removal of the urethral catheter and before the suprapubic tube is dispensed with, the urethra should be calibrated to an F 24. This can easily and effectively be accomplished by the gentle and periodic passage of well lubricated soft rubber coudé catheters of increasing size. I have found it advantageous to begin with an F 14 catheter and periodically every two to three days use the next larger-sized catheter, namely, F 16, 18 and so forth. The indwelling silk suture is an excellent means of passing these catheters through the urethra and bladder by the "railroad technic." The silk suture should be completely removed when the urethra has been calibrated to an F 24. After the patient has begun to void following the removal of the suprapubic tube, the vesical neck and urethra should then be dilated every ten to twelve days. This can easily be accomplished by the gentle passage of a well lubricated F 18 to 20 soft rubber coudé catheter. The use of metal sounds and hard rubber catheters are contraindicated since they tend to traumatize the urethra and lead to late cicatrization. Dilata-



10A 10B

FIG. 10. This case was managed in accordance with the principles outlined in this paper. It illustrates the excellent urologic findings three years after the injury. A, excretory urography showing normal upper urinary tracts and a normal, well positioned bladder. B, cystourethrogram discloses a normal calibrated urethra free of stricture and tortuosity.

tion of the urethra should be continued for three months. At this time further dilatation may be dispensed with if there is no evidence of stricture as determined by the easy passage of a urethral catheter without the sensation of a "hang" and by retrograde urethrography demonstrating normal contour of the urethra without narrowing or distortion.

Stricture formation has been recognized as a common sequel to traumatic rupture of the urethra and/or the vesical neck.[9] If this eventuality occurs, dilatation of the cicatrized area at stated intervals is mandatory for the remainder of the patient's life. Experience in my last three cases of avulsion of the bladder neck, managed in accordance with the routine outlined for this condition, reveals that there was no evidence for stricture in any of the patients. These cases have now been followed up for a sufficient length of time, two for three years and one for two years, to justify the belief that if managed correctly, traumatic avulsion of the vesical neck and prostate need not be complicated by stricture. (Fig. 10.)

RESULTS

The routine management of avulsion of the bladder neck and prostate as outlined herein has now been used in three patients. It has impressed me as being simple, safe and practical. The postoperative course was uneventful in all cases. Follow-up studies at the end of three years in two cases and at the end of two years in one case has revealed that the end result has been excellent in all. Each had anatomically perfect alignment of the vesical neck and urethra, and each was free of stricture or other urologic complication. No persistent urinary tract infection was encountered in any of the patients so treated.

SUMMARY

Failure to correct the anatomic deformity of avulsion of the bladder neck and prostate because of delayed, incomplete or improper management leads to an irreparable lesion forever incapacitating the patient.

This traumatic lesion should always be considered as being present until proved otherwise

in those cases in which severe disruption of the pelvic architecture exists, especially when due to lateral crushing injuries. The diagnosis of avulsion can be established immediately by the rectal examination which discloses that the prostate is exceedingly mobile and higher than normal. Recourse to any other diagnostic procedures is unnecessary.

Review of our early cases of avulsion of the bladder neck revealed that complications were encountered in the postoperative period and as late sequelae. This led to the formulation of a routine method of treatment to avoid the pitfalls in the urologic management of these patients. This routine is an orderly and rational approach to certain definitive principles of treatment and to the meticulous detail which I have found necessary in the use of drains, the management of the indwelling catheter and the selection of antibiotics.

This routine has now been employed in three successive cases. It has proven to be simple, safe and practical. Follow-up studies of these patients has revealed the absence of complications in the postoperative period and of late sequelae. The end result was excellent in all. Experience with this routine as a method of management in this type of lesion certainly justifies its universal acceptance.

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Treatment of Traumatic Ulcers of the Lower Extremities

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TRAUMATIC recalcitrant ulcers of the lower extremities are the result of trauma, infection and inadequate blood supply; this process results in the formation of dense fibrous connective tissue. It can be interrupted only by excision of this abnormal tissue down to a base that will permanently support some type of epithelial graft.

Gunshot and schrapnel wounds, burns, irradiation, decubitus ulcers, foreign bodies, trauma superimposed on varicosities and large avulsions are direct causes of these ulcers.

Many schrapnel wounds are quite extensive, frequently accompanied by compound fractures with exposure of tendons and joints, and loss of bone and large areas of skin. If these wounds are allowed to heal following débridement without adequate skin coverage, a chronic ulcer will likely result.[1]

FIG. 1A to D. A British officer received a schrapnel wound of the tibia in Africa. A, chronic ulcer with 10 cm. of tibia absent one year later. B, ulcer excised and cross leg flap elevated. Defect from which flap was elevated covered with split skin graft. C, flap sutured to defect with no delay of graft. Notice the wide base to insure good supply to graft. D, pedicle put "on and off" in two operations. Incision in center of graft through which bone graft was placed.

An unhealed schrapnel wound of the left leg that was allowed to heal without adequate skin coverage is seen in Figure 1. This wound was initially débrided, packed with vaseline gauze and placed in plaster. Approximately 4 inches of tibia were lost by the missile, débridement and infection. Frequent change of casts and

packs was carried out while waiting for definitive surgery. In preparation for a bone graft to the tibia a cross leg pedicle graft was done in two stages. The first included elevation of the pedicle and immediate transference to the soft tissue defect after excision of the scar. The second was complete severance of the flap without surgical delay. Several months later a tibiofibular transplant and an inlay bone graft were done. The patient has been symptom-free for the last four years.

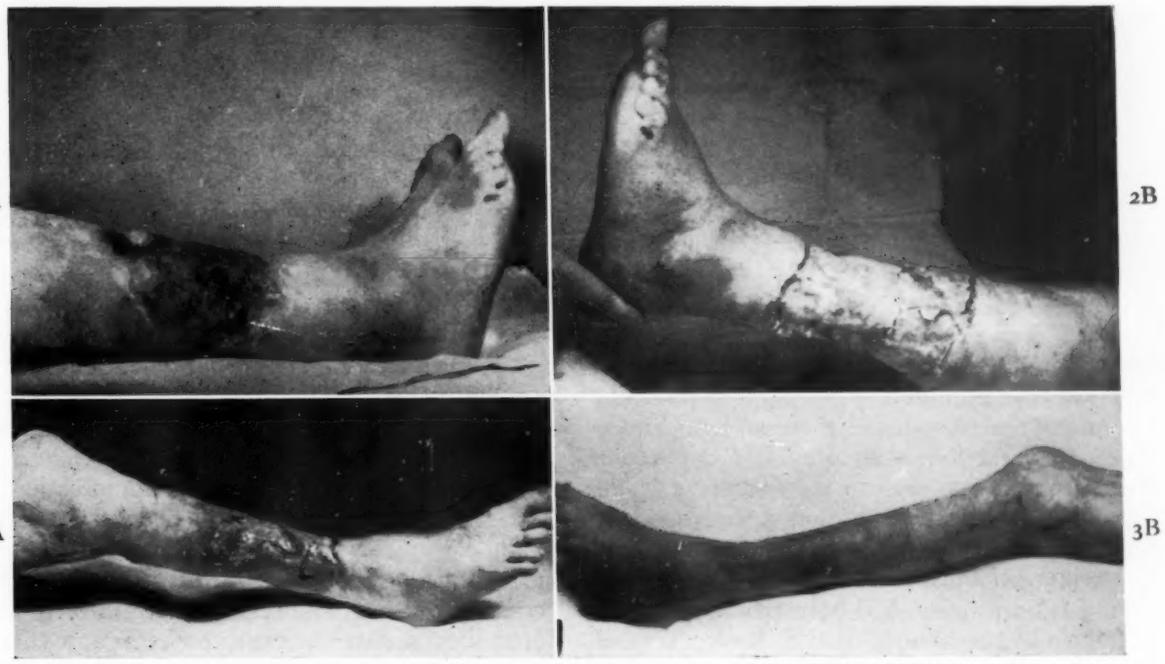
Chronic ulcers resulting from burns are the result of failure to graft when indicated. These ulcers are usually circumferential burns of the legs which have developed a very dense fibrous tissue base with an exceedingly poor blood supply. This defeats epithelization and, as time goes on, the edges become elevated and rolled. These may degenerate into Marjolin's ulcers.[2]

Failure of skin grafts to cover these areas is usually the result of inadequate excision in preparing the bed for the graft. Grafts placed on a dense fibrous tissue base will not grow due to poor source of nutrition for the graft.

An ulcer of this type is seen in Figure 2. This is a fifteen year old burn that was never grafted. In one operation the entire area was excised and a split skin graft applied. The

1E

FIG. 1E. Tibiofibular transplant and an inlay bone graft; patient was discharged as cured in August, 1951.



2A 2B 3A 3B

FIG. 2. A, chronic burn ulcer present for fifteen years which never completely healed. B, after excision of scar down to fascia and covered with split skin graft. Graft stable when followed up for two years.

FIG. 3. A, this burn ulcer was present for ten years and amputation had been advised following failure of conservative grafting procedures. B, leg was covered in two operations and remained healed for five years.

4A 4B 5A

5B 6A 6B

FIG. 4. A, a seventy-three year old patient with irradiation defect of foot. X-ray given thirty years previously for fungous infection. Several excisions and closures were performed for ulcer adherent to tendon. B, demonstrates the use of rotation pedicle flap and split skin graft to donor site. Lesion healed when followed up for three years.

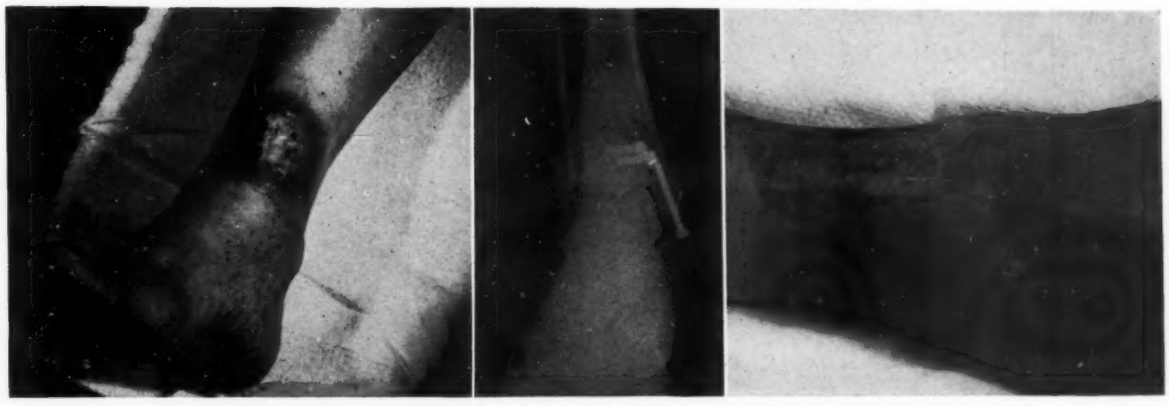
FIG. 5. A, irradiation ulcer of heel which failed to heal with excision. B, defect closed with cross leg flap and has remained healed for five years despite the patient's weight of 240 pounds and his occupation as bartender.

FIG. 6. A, ulcer present for eight years following the application of a cast for compound fracture of ankle. Several excisions and grafts were done. B, cross leg flap done in two stages following radical excision of fibrous tissue base. It has remained healed for three years.

excision consisted of the removal of fibrous tissue which extended to fascia and muscle; this was approximately 4 cm. in thickness. The entire graft survived and there was no breakdown during a follow-up period of two years. No carcinoma was seen in the specimen.

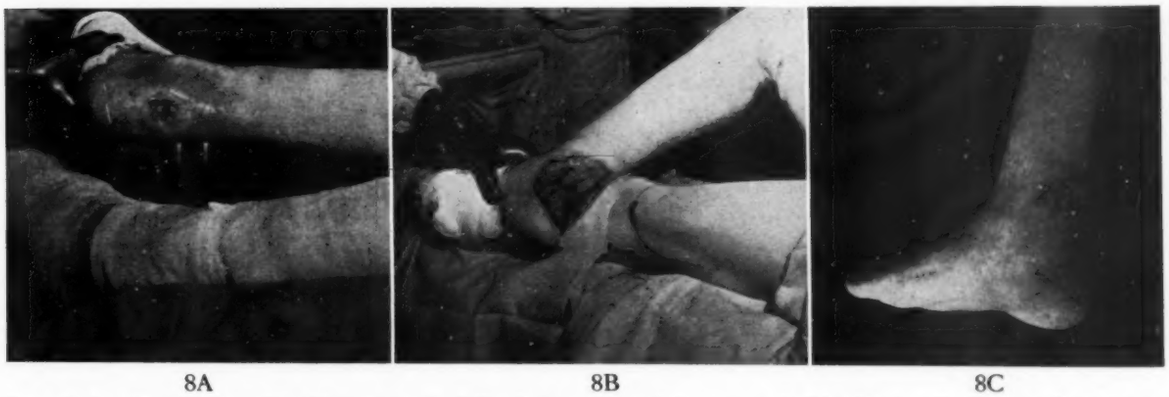
Another example of chronic ulcer secondary to a burn is the case of an eighteen year old boy who was burned when ten years of age. (Fig. 3.) Amputation had been advised because of failure of the area to heal following several grafting procedures. The leg was covered in two operations with split skin grafts after a thorough excision of all fibrous connective tissue down to fascia. The patient has been followed up for five years and there have been no complications.

The case shown in Figure 4 is presented to illustrate the use of a rotation flap in combination with a split skin graft. The patient was given x-ray therapy for a fungous infection of the foot thirty years before. Several excisions and closures were performed for recurrent ulcers and binding scar during that time. This continued to recur because of trauma to the area, inadequate excision and radiation effect. The tendons were exposed following radical excision of the involved tissue and this necessitated a pedicle graft. The tendons were covered with skin and fat by a rotation pedicle graft



7A 7B 7C

FIG. 7. A, a chronic decubitus ulcer following the application of a cast for compound fracture and failure to heal due to low grade infection and foreign body. B, x-ray showing screws that probably contributed to healing failure. C, defect excised and closed with a split skin graft which has remained healed for one year.



8A 8B 8C

FIG. 8. A, ulcer present for thirteen years following compound fracture of tibia. Two split skin grafts were attempted. B, ulcer excised and flap designed on opposite thigh. The flap was not delayed. C, the flap healed on the medial side of the foot and the lateral side was split skin grafted because of loss of the flap even with delay. This lesion is now completely epithelized.

on the anterolateral surface of the foot. The defect from which the flap was rotated was covered with a split skin graft. This lesion has remained healed with a good functional result during a three-year follow-up period.

An x-ray ulcer seen in Figure 5 is located on the plantar surface of the heel. This was excised and found to extend to the os calcis. The lack of mobility of tissue in this region prevented an adequate local source for covering the bone. This area was covered with a cross leg flap and has remained healed for five years.

A large number of ulcers are due to improperly applied casts following compound fractures with or without soft tissue loss. One such ulcer, present for eight years after application of a cast for a fractured tibia, can be seen in Figure 6. Numerous split grafts were applied without success. Because all dorsal tendons were exposed by complete excision of the fibrous tissue, a pedicle graft was necessary. Since the patient was a female, the pedicle was elevated from the opposite calf with reluctance because of the future residual scar. This site was used, however, because of the comparative ease of transplantation and the fact that only two operations were required. The ulcer has remained healed for two years and the donor site is not objectionable.

An ulcer due to a combination of cast irritation and foreign body is seen in Figure 7. This patient sustained a compound fracture of the ankle with soft tissue loss. An open reduction was obtained by fixing the fragments with screws and wire. The screws became exposed through devitalized tissue which had become severely traumatized at the time of injury. Eventually there was complete loss of coverage

9A 9B

10A 10B

FIG. 9. A, ulcer resulting from industrial accident. This failed to heal because of venous stasis. B, healed leg after Linton procedure and split skin grafts following loss of edges of flap due to impaired blood supply.

FIG. 10. A, trophic ulcer of heel present for eight years following removal of tumor in thigh. B, cross leg flap covered defect after removal of infected bursa exposing os calcis.

over the dorsum. The screw that was protruding into the wound was removed, the scar excised and the defect covered with a split skin graft. There was complete take of the graft and no complications were observed during the following year.

A chronic ulcer that was present for thirteen years is seen in Figure 8. This resulted from a combination of loss of tissue, compound fracture and cast application. Two unsuccessful attempts were made to cover the lesion with split skin grafts. A cross thigh flap was placed on the medial surface of the foot after all scar tissue was excised. The superior portion of the flap, which was applied to the lateral surface of the foot, was lost due to poor blood supply, even though the flap was delayed several times prior to detachment. Split grafts were used to cover this surface and there was complete healing.

Slight trauma added to an already impaired blood supply to the lower extremity may cause ulcers which fail to heal permanently. Such an ulcer (Fig. 9) is the result of a piece of metal striking the leg while the patient works. This ulcer failed to heal because of the presence of severe venous stasis. The location of the ulcer was on the anterior surface of the leg at the site of trauma. This ulcer was previously treated with saphenous vein ligation and supportive stockings.

A modified Linton procedure[3] was performed by removing the ulcer and all varicosities down to the fascia from the knee to the ankle. Portions of the skin flaps were lost because of infection and impaired blood supply. Skin grafts were applied and these healed without further complications.

Ulcers resulting from interruption of nerve supply, particularly on the plantar surface, are very recalcitrant to therapy. The ulcer seen in Figure 10 had been present for eight years without healing. At the time of excision a large bursa that extended to the os calcis was found.

The required pedicle graft was taken from the opposite thigh. Great care must be exercised postoperatively to prevent any pressure on the graft because the area remains anesthetic. Ulceration of the graft can be prevented by the use of a foam rubber pad that allows pressure on surrounding tissue.

CONCLUSIONS

Invalidism resulting from chronic leg ulcers can be prevented by the application of principles of tissue transplantation. It is imperative that an appreciation of the extent of skin loss be made at the time of injury and the wound adequately covered as soon as possible.

All too often an attempt is made to close a wound with traumatized tissue. This results in a high incidence of failures. It is far better to cover immediately with a skin graft than to have a breakdown of the wound following inadequate closure. This is especially true in a compound wound. Early adequate closure of wounds prevents infection, further tissue loss and the formation of extensive fibrous connective tissue that further diminishes the blood supply to the area. It should be emphasized that although fundamentals of wound closure have been advocated many times in the past, early adequate closure must continue to be stressed because failure to recognize this principle is responsible for those preventable cases that continually present themselves.

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DISCUSSION OF PAPERS BY DRS. CURRY AND LYTTLE, STONE AND LORD, ORKIN, AND KIEHN AND SCHATTEN

Nicholas J. Giannestras (Cincinnati, Ohio): I should like to compliment the essayists on their good papers. I am particularly interested in Dr. Lyttle's paper. Insofar as the acromioclavicular separation is concerned, primarily I cannot agree with him that the outer section of the clavicle should be performed with acute acromioclavicular separations, no matter how severe, since conservative therapy will, in a large majority of cases, produce a normally functioning acromioclavicular joint.

Those dealing with football players will find that they have recurring acromioclavicular separations and they continue to participate in athletics without any difficulty or pain.

In chronic acromioclavicular separations which are symptomatic, resection of the distal end of the clavicle is a very fine procedure, and an excellent functioning shoulder will result.

One must admit that a football player's shoulder takes more punishment than the average individual's, no matter how hard a laborer he may be, and there have been instances (as in three such patients I have seen) where resection of the outer third of the clavicle was performed because of a painful shoulder. They have been able to continue their athletic careers without any difficulty.

Insofar as regeneration of the clavicle is concerned, it may sound very strange but it does occur in children, and I will go along with Dr. Lyttle on that completely.

Resection is a good procedure for fracture of the olecranon process, and it is surprising how much of the olecranon you can sacrifice and still have a perfectly stable elbow joint.

Regarding total patellectomy, it is important that one must remember that imbrication of the patella tendon to the quadriceps extension should be carried out in order to maintain good function of the quadriceps muscle. There have been reports of unsuccessful patellectomy resulting in a poorly functioning knee, particularly as far as extension is concerned. However, if one is careful in the repair of the patella tendon to the quadriceps extension and will take up the slack which is left because of the absence of the patella, such a knee will function very satisfactorily.

Drs. Lord and Stone's paper was of interest to me because such a situation can occur, and one can develop these neurologic and circulatory changes in a malunited clavicle. Correction of the malunion can overcome them.

Ralph G. Carothers (Cincinnati, Ohio): I was particularly delighted with Dr. Lyttle's paper because Dr. Gurd, as he mentioned, read his paper in this very room seven years ago. It made a tremendous impression on me and I remember almost every word of it.

I would like to discuss one phase of Dr. Lyttle's paper, and that is dislocation of the outer end of the clavicle. I have performed every operation ever heard of for that, and the only one found to be any good is excision. There is a conservative method of treatment which I have tried, and which works, but is very expensive. It means eight weeks of hospitalization, during which time the patient remains in bed with his arm raised.

I know that Drs. Giannestras and Thorndyke in dealing with football players have some different ideas; but when this football institution is devel-

oped a little higher and the players join the C.I.O. or the A.F.L., I think some of those injuries will be slower in healing.

DONALD M. GLOVER (Cleveland, Ohio): I would like to mention first the excellent presentation of Dr. Kiehn who has very ably called attention to the often neglected ulcers of the distal extremity, and unsuccessful attempts too commonly employed in inadequate excision of avascular tissue in the presence of these chronic ulcers which may be due to long-standing results of trauma, to irradiation or to vascular impairment; particularly, the latter group require the greatest care in adequate excision of the avascular scar which will otherwise defeat any attempt at replacement.

I would add one thought, particularly with regard to the avascular areas, as a result of venous impairment or a combination of venous and arterial impairment: Regardless of how well replacement is carried on with either split-thickness or full-thickness skin, many of these require long-standing support. Carefully made sponge rubber pads, together with elastic stockings or elastic bandages worn by these individuals for a period of years after replacement, may save breakdowns because we know that the avascular scar eventually may defeat even the most effective replacement by the plastic surgeon.

I would like to comment also on the excellent presentation of Dr. Orkin and merely remind ourselves again what is patent; i.e., in combined injuries which may involve the abdomen or pelvis in unconscious patients who have suffered an unknown amount of trauma, it is very important to place a catheter in the bladder immediately regardless of whether or not the bladder seems to have been injured. This was highlighted recently by a patient who entered our hospital apparently intoxicated and unconscious, with a head injury and an amount of abdominal trauma which was rather indefinite.

Failure to attempt to place a catheter in the bladder immediately resulted in a serious delay in diagnosis of injury to the bladder which ultimately resulted in fatal peritonitis following delayed repair of the ruptured bladder. This could unquestionably have been obviated by immediate investigations and the simple expedient of catheterization.

I would like also to comment favorably on the excellent presentation of Drs. Curry and Lyttle, and just add that I hope the "throw-away" part of the published summary is not quite literal. I hope that they maintain a bone bank for these very useful fragments which can be employed elsewhere to advantage.

JOSEPH M. DZIOB (Buffalo, N. Y.): Dr. Orkin has accomplished his objective very well, namely, "to help eliminate the many pitfalls inherent in the treatment of this very serious injury."

Bony pelvic injury in itself offers no real problem in treatment; but where one is confronted with avulsion of the bladder neck associated with pelvic fracture, that demands real care.

However, this problem, too, readily resolves itself if one will follow the exacting dictates that he has promulgated, namely, diversion of the urinary stream, drainage of the deep pelvis and restoration of urethral continuity.

This routine that Dr. Orkin has presented is actually the summation of the progress of treatment of fracture of the pelvis associated with bladder avulsion as it is depicted in the literature.

Initially, the treatment was suprapubic cystostomy associated with suprapubic drainage. It was almost immediately recognized that the incidence of deep pelvic infection was very great, and so deep pelvic drainage was added to the treatment.

The difficulties associated with restoration of urethral continuity as a secondary procedure were almost insurmountable, and therefore the problem of restoring continuity as an initial procedure arose. Retrograde catheterization, which is the method depicted here and which was introduced by Banks, takes care of this problem very well when the retrograde catheterization is carried out in the initial procedure. Still, even though one passes a catheter by retrograde catheterization, it is apparent, if one consults the literature, that stricture in the membranous or posterior portion of the urethra is a very common sequela and one notes that catheterization throughout the lifetime of the individual is necessary.

It would appear from the presentation that Dr. Orkin is emphasizing a very essential point when he employs traction on the bladder neck through the Foley catheter together with suture of the apex of the prostate to the pelvic floor in order to maintain continuity of the severed ends of the urethra. According to his last three cases, injections of the urethra postoperatively and in follow-up examination have shown that there has been no need for dilatation since there is no evidence of stricture. This, I believe, is a very important advance in the treatment of this serious injury.

I have enjoyed Dr. Orkin's presentation tremendously and I think he is to be commended highly for the scholarly manner in which he has standardized the treatment of this very, very serious injury. It is my conviction that this will be the type of paper which one should file and consult when the rather unusual occasion arises that one must deal with a fracture of the pelvis associated with avulsion of the bladder neck.

FRASER N. GURD (Montreal, Canada): Dr. Lord has introduced a further indication for dispensing with the clavicle to be added to the indications put forward by Dr. Fraser B. Gurd in 1947.

My father began his career as a protagonist for

the removal of surplus parts of the skeleton following successful excision of a sarcoma of the clavicle. The excision was wide and the reattachment of muscles to one another was makeshift, but the excellence of the functional result was cause for some amazement.

A good many gentlemen here may recall the discussion which followed his presentation in 1947. In the amiable and vigorous fashion of this society he was subjected to considerable teasing. I recall that Dr. Magnuson remarked in effect that he did not think a man without a clavicle was necessarily better than a man with one. The discussion closed on a merry note when my father replied that perhaps the time would come when Dr. Magnuson would have had enough experience with fractures to realize the validity of his thesis.

CHARLES S. NEER, II (New York, N. Y.): I think we should commend Drs. Lyttle and Curry for a very interesting paper. Certainly it is well to emphasize that a part of almost any bone from the phalanx to the sternum can be discarded without handicapping most patients very much.

There are three areas about which I would like to comment particularly. The first is the upper humerus. I think we have to agree that the humeral head was justifiably removed by Dr. Lyttle in his patient. Furthermore, we agree that the results of excision of the humeral head, as in this case, have not been very good. I believe there was only 30 per cent abduction following removal of the head. In our paper we intend to say that replacement of the humeral head, at least as far as the early results indicate, improves the result over limited resection. This is not so if the tuberosities have to be removed as well as the head, as is the case with certain tumors.

Secondly, let us consider the acromioclavicular joint. We must disagree a bit with Drs. Lyttle, Giannestras and Carothers with regard to the treatment of acromioclavicular separations. In young patients we prefer to reduce the dislocation and transfix the joint with pull-out wires, believing that we can restore normal anatomy if this is done early. We have not seen our way to excising the outer clavicle in younger patients.

Thirdly, with regard to olecranon fragments, I think it might be added that the excision of these fragments should not be looked upon as a routine procedure and that in many situations they are of value in the repair and do no harm.

I am glad that no situation was shown where a weight-bearing part of the lower extremity was excised. Excision of femoral heads for fresh fractures has been used too indiscriminately throughout the country.

I would like to make one other remark with regard to Dr. Lord's paper. Experience with grafting non-union of the clavicle indicates that the subclavian vein can be involved in the scar, and the one who sets out to operate upon this bone must be prepared for a little extracurricular activity.

ESLIE ASBURY (Cincinnati, Ohio): The Chair would like to remark that in Cincinnati we have seen two people with complete, congenital absence of both clavicles. They can put their shoulders completely together and have no apparent disability whatsoever.

I saw a patient in 1928 who had had a very badly comminuted fracture of the clavicle with non-union and no symptoms after several years. One day while poking the furnace he had a sudden severe pain due to tearing of the subclavian vein. At operation I really did not know he had torn the subclavian vein because there had been at that point nothing but the tear and the blood had been held back by the scar tissue. In fact, I thought a clavicular fragment had caught a part of the brachial plexus. I excised the rough ends of the clavicle as a temporary measure, but the patient did so well nothing further was necessary. Since that time I have excised a great many severely comminuted clavicles with excellent results.

Two-plane Fixation of Fractures of the Femoral Shaft with Eggers' Plates

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TWO-PLANE fixation of fractures of the femoral shaft is performed by applying Eggers' plates[1] to the anterior and lateral aspects of the bone to hold the fragments in position until union has taken place. The advantages of this method of open reduction are many.

The femur is surrounded by heavy, powerful muscles. Fractures which occur anywhere along the shaft are not only hard to reduce by older conservative methods but also are very difficult to maintain in place by balanced skeletal traction. Constant observation and frequent x-ray checks are necessary in order to keep the fragments aligned. Distraction, delayed union, non-union, malunion and stiff knees frequently result from this method of treatment. Fractures of the femoral shaft, treated conservatively, require long periods of immobilization (ninety days or more). The cost of hospitalization and of time lost from work adds to the patient's burden.

Altogether, conservative methods of treatment for fractures of the shaft of the femur have given such poor results that they are gradually being supplanted by the more radical procedure of open reduction with firm fixation of the fragments.[2] Today's better understanding of shock, blood replacement, and fluid and electrolyte balance has sharply reduced the mortality rate from open reduction, and the use of antibiotics and good surgical technic has reduced the incidence of infection. Open reduction gives far better results in terms of function.

PATHOLOGY

Because of the pull of the different muscles, fractures of the femoral shaft, with displacement, have different characteristics depending on whether they occur in the upper, middle or lower third of the femur.

Fractures of the Upper Third. When a fracture occurs in the upper third of the femur, the proximal fragment, if displaced, is abducted, externally rotated and flexed on the abdomen. Because the short proximal fragment cannot be manipulated, reduction by traction is quite difficult and rarely accomplished. The nearer the break is to the trochanters, the more difficult it is to reduce. This fracture nearly always ends up requiring an open reduction. Non-union in this area is uncommon, but after the sixth decade it carries a high mortality rate. In a previous review of fifty-one fractures of the upper third of the femur treated at Charity Hospital,[3] it was pointed out that the mortality rate was 25 per cent when the fracture was treated conservatively and 16 per cent when treated by open reduction.

Fractures of the Middle Third. Fractures of the femoral shaft most commonly occur in the middle third. When displaced, the proximal fragment is abducted and externally rotated. The distal fragment is adducted, overrides the proximal fragment and assumes a medial posterior position. The results of conservative treatment are better in this area than in the upper and lower thirds of the femur because both fragments are long and more easily handled. The end results in many cases, however, leave much to be desired.

Fractures of the Lower Third. When a fracture occurs in the lower third of the femur, the distal fragment, if displaced, is angulated posteriorly by the pull of the powerful gastrocnemius muscle. The overriding is caused by all the muscles that cross the fracture line, the quadriceps and the hamstrings. The medial or lateral displacement is often due to the fracturing force. The closer the fracture is to the condyles, the more difficult it is to control the distal fragment. Delayed union and non-union are common in this area. This is especially true after the fifth decade because of the atrophy of the cancellous bone. At open reduction the

shell-like cortex of the distal fragment often presents itself as a thin hollow pipe.

TWO-PLANE FIXATION

Indications. The indications for two-plane fixation are practically the same as for medullary nailing.[4] By means of two-plane fixation, however, comminuted fractures and fractures near the greater trochanter and low near the condyles can be fixed more firmly than with the long nail. This is one of the chief advantages of this method of fixation.

Open reduction is indicated for (1) transverse, oblique, short spiral or short comminuted fractures which are located in the area reaching from 2 inches below the lesser trochanter to 3 inches above the condyles; (2) open fractures which are not grossly contaminated, provided soft tissue damage has been minimal, and if the patient is seen within the first four to six hours; (3) delayed union, non-union and malunion; (4) fractures resulting from Paget's disease (osteitis deformans) or from metastatic carcinoma; and (5) multiple fractures (such as the coexistence of a shaft fracture and a neck or intertrochanteric fracture on the same side), or the presence of other coexisting injuries (such as burns on other parts of the body). As Smith[5] has pointed out "the problem of multiple and frequent dressings or other surgical procedures where the patient has to be moved to the operating room can be immeasurably simplified if cumbersome apparatus can be obviated by stable internal fixation."

Contraindications. The contraindications to two-plane fixation are:[4] (1) gross swelling and fever; (2) gross contamination of open fractures; (3) infection of the skin or potentially infectious conditions of the skin of the thigh, such as the presence of furuncles, abrasions, burns or blebs; (4) youth of the patient. Fractures in children under fifteen years of age present different problems from those in adults. Good results, with restoration of length, may be obtained in children by conservative methods after a year or two even though the fracture has healed with overriding. Internal fixation may be performed on patients younger than fifteen if other injuries coexist which require mobility.

Advantages of the Eggers' Plate as a Fixing Agent. The first essential of a good fixing agent is sufficient strength to withstand the shearing force of muscle pull at the site of fracture. The agent must maintain position, prevent rotation, hold the fragments in close opposition, allow impaction, and, at the same time, cause only a minimum of interference with blood supply and the normal physiology

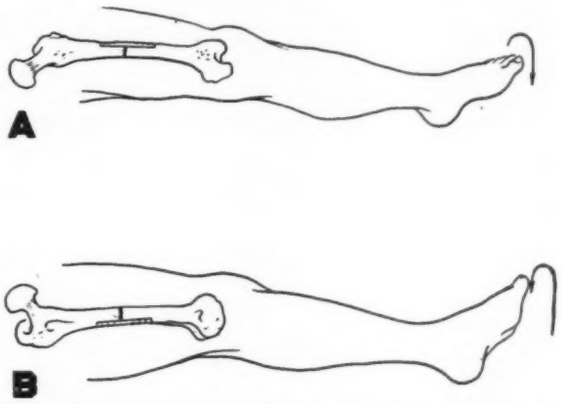

FIG. 1. To apply the anterior plate, the foot is rotated externally. To apply the lateral plate, the foot is internally rotated 15 to 20 degrees. A, drawing showing anterior plane of shaft of femur. B, drawing showing lateral plane of shaft of femur.

of bone regeneration and union. The device must be fairly free from complexities. Two-plane fixation with Eggers' plates meets most of these requirements and is a fairly simple and efficient means of holding the fragments in place until firm union has taken place. Only one length plate is necessary, and the ordinary instruments that are normally present in an operating room for an open reduction are all that are needed.

The advantages of two-plane fixation are (1) accurate anatomic fixation, (2) optimum conditions for impaction, (3) firm rigid fixation without rotation, (4) freedom of hip and knee motion, (5) short hospitalization, and (6) early ambulation.

When we first used two-plane fixation, we used a four and a half inch six-hole Lane plate. Because, theoretically, Lane plates may maintain distraction, we have used 5 inch Eggers' plates in forty-one of our most recent cases. This plate has many advantages over the Lane plate. It allows impaction of the fragments. Because of its slot there is less danger of breaking a drill point and, if this should occur, the point is easier to retrieve. If the drill point cannot be removed, another drill hole can be made along its side.

It is rarely necessary to remove the plates;

2 3 4 5

FIG. 2. Patient was a sixty-nine year old white woman. Upper third fracture occurred in 1946; mid-third fracture in 1953.

FIG. 3. A fifty-three year old Negro man. Intertrochanteric and lower third fracture two years postoperatively.

FIG. 4. A forty year old Negro man. Intracapsular and mid-third fracture two years postoperatively.

FIG. 5. A fifty-seven year old white man with Paget's disease. Intratrochanteric and mid-third fracture two years postoperatively.

in eighty-one fractures we have not removed any.

TECHNIC

When a patient with a femoral fracture is first seen, traction is applied, although no real attempt is made to reduce the fragments. Later the Thomas splint makes it possible to transfer the patient to the operating room without loss of traction. The patient is placed on a fracture table and both feet are made fast to the extended stirrups. Just enough traction is applied to keep the injured extremity from sagging. The affected extremity is prepared and draped.

For fractures in the upper third the approach of Henry[6] is employed. An incision is made from the anterior superior iliac spine downward anteriorly and laterally for about 18 inches. The incision is carried down through the fascia lata. The interval between the vastus lateralis and the rectus femoris is found about 6 to 8 inches below the greater trochanter, and the muscles are separated. The important anatomic structures are the descending branch of the lateral femoral circumflex artery, along with its companion vein, and the nerve to the vastus lateralis. These cross in front of the shaft just below the lesser trochanter and pass obliquely downward. The whole vasculo-nervous bundle should be drawn upward. In the usual lateral approach both vessels and nerve are divided, causing unnecessary hemorrhage and interference with the life of the muscle.

When the fracture is in the middle or lower third, an anterior lateral approach is used.[6] The incision is made along the margin of the rectus femoris. Again the interval between the rectus and vastus lateralis is found and the muscles separated. The rectus is retracted medially and the vastus lateralis downward. The vastus intermedius is split in the direction of its fibers, exposing the femoral shaft. The tendons of the muscles about the lower third of the femur are

6 7

FIG. 6. An eighteen year old white boy. Marked comminuted mid-third fracture.

FIG. 7. Follow-up x-ray of patient in Figure 6 showing the result eight months postoperatively.

very closely adherent to the bone and must be separated by sharp dissection. Entering the suprapatellar bursa can be avoided by keeping close to the shaft of the bone.

After the bone has been exposed, the muscles are packed off with warm cloths to avoid drying and further injury. The proximal and distal fragments are pulled into the wound, angulated and approximated. Because the proximal fragment is always externally rotated, the distal fragment is also externally rotated and the ends allowed to fit together. This permits physiologic impaction by muscle pull and also projects the anterior plane of the femur into the wound.

After reduction, the anterior plate is bent slightly to conform to the curvature of the shaft. Screws should not be used for bending because unequal tension will cause the screws to work loose. The plate is made fast to the femur with six screws. Following the application of the anterior plate there is considerable stability of the fragments. To expose the lateral aspect of the femur, the foot is rotated internally 15 to 20 degrees. (Fig. 1.) Again the plate is bent to the correct contour and made fast to the bone. The soft structures are then reapproximated around the femur. No other type of fixation or traction is necessary.

The patient is allowed to be up in a wheelchair the day following fixation. Quadriceps and knee-bending exercises are begun on the second day. On the seventh day patients are allowed to walk, with crutches and partial weight-bearing, on the affected extremity. They are checked for progress with x-ray studies every two months. Braces are not used.

RESULTS

Since 1946 we have performed eighty-one two-plane fixations for fractures of the shaft of the femur on seventy-nine patients. (Figs.

2 to 7.) One patient had a bilateral femoral shaft fracture. Another, who had had a fracture of the upper third of the femur, sustained a fracture of the middle third seven years later.

Of the eighty-one fractures, twenty-two were in the upper third, forty-five in the middle third and fourteen in the lower third of the femoral shaft.

The youngest patient was fourteen, the oldest eighty-three years of age.

There were eight fractures in bones weakened by disease, three secondary to metastatic carcinoma of the breast and five secondary to osteitis deformans. All of the fractures in patients with Paget's disease went on to union. Patients whose fractures were secondary to breast carcinoma died shortly after fixation, one five months after. All were comfortable as far as the fracture was concerned and could be moved from bed to chair.

There were three cases of wound complications. A hematoma developed in the wound of a thirty-eight year old white man. Following the aspiration of 100 cc. of blood, the wound healed. A superficial wound infection, which healed following incision and drainage, developed in a twenty-seven year old Negro man. In another patient, a twenty-four year old Negro man, a slight amount of seropurulent drainage from the lower end of the incision developed, which healed spontaneously without drainage.

One patient broke the anterior plate and required immobilization in a plaster spica.

There were two deaths. An eighty-three year old white woman, with a fracture secondary to metastatic breast carcinoma, died of myocardial failure on a subsequent admission to the hospital. A fifty-nine year old white woman with severe cardiac disease and diabetes developed hyperpyrexia and coma postoperatively and died on the fourth postoperative day.

SUMMARY

Two-plane fixation for fractures of the femoral shaft is a method of applying Eggers' plates to the anterior and lateral aspects of the femur to hold the fragments in position until union has occurred. Open reduction can thereby be achieved with a minimum risk of death or infection.

The advantages of two-plane fixation are (1) accurate anatomic fixation, (2) optimum conditions for impaction, (3) firm rigid fixation without rotation, (4) freedom of hip and knee motion, (5) short hospitalization, and (6) early ambulation.

Eighty-one dual platings in seventy-nine patients have been analyzed. There were two deaths in the series and three minor wound complications. One patient broke the anterior plate and required immobilization in a plaster spica. All fractures except those due to metastatic malignancy united. It was not necessary to remove any of the plates.

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An Adjustable Fixation Device for the Hip

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THIS is a report on the use of adjustable internal fixation for the hip over a ten-year period on the Fracture Service of The Presbyterian Hospital in New York City. Two hundred and twenty fractures and osteotomies at the hip have been treated by this method. One hundred and twenty five records, which were documented at least until after sound bone union had occurred, have been assessed in an effort to evaluate this principle of treatment.

In 1946 it was suggested that an adjustable device would have advantages over the fixed angle instruments then in use for internal fixation of intertrochanteric fractures.[1] It was postulated that such an appliance could be fitted to the fracture, rather than the reverse. This has been confirmed by clinical test. Adjustable fixation has facilitated greatly the

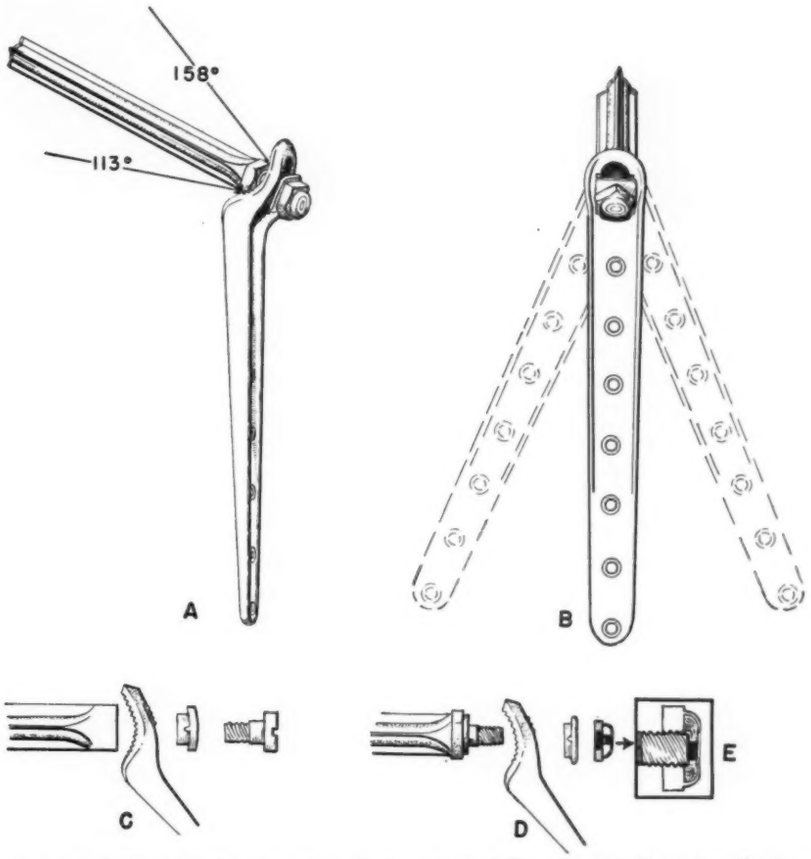
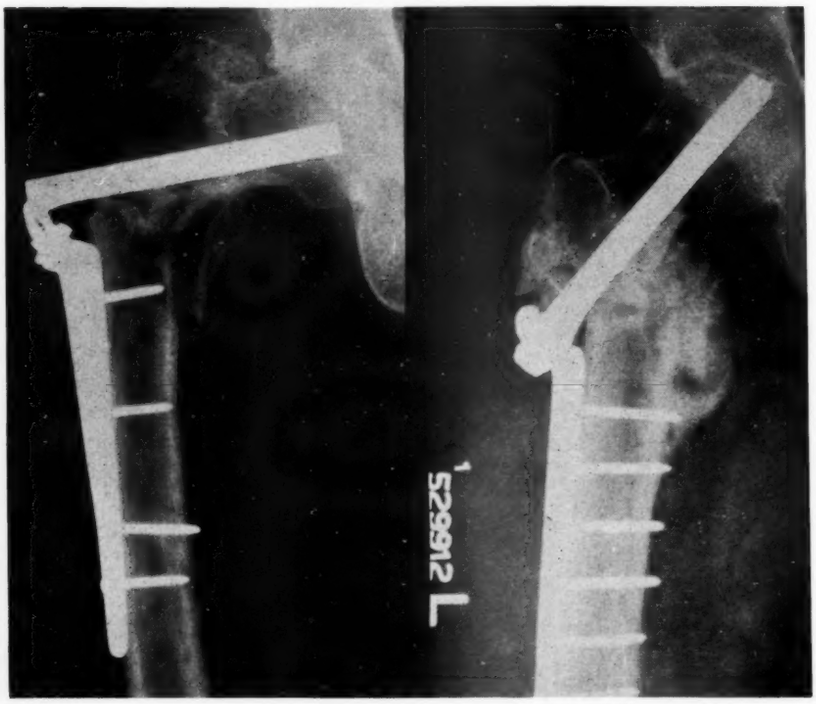


FIG. 1. Adjustable hip fixation device. A and B, adjustability of nail-plate relationship is available in two planes. C, undependable "set screw" locking mechanism. D, dependable "stop nut" locking mechanism. E, the "stop nut" with enclosed elastic washer which, when compressed by stud, prevents loosening.



2A 2B

FIG. 2. A, unstable fracture of one year's duration. Fixation lost after one week, reapplied and again disrupted, then treated by traction. Note loose "set screw." B, osteotomy and fixation by modified "stop nut" device.

stabilization of all types of intertrochanteric fractures, as well as pure subtrochanteric lesions and high femoral osteotomies.

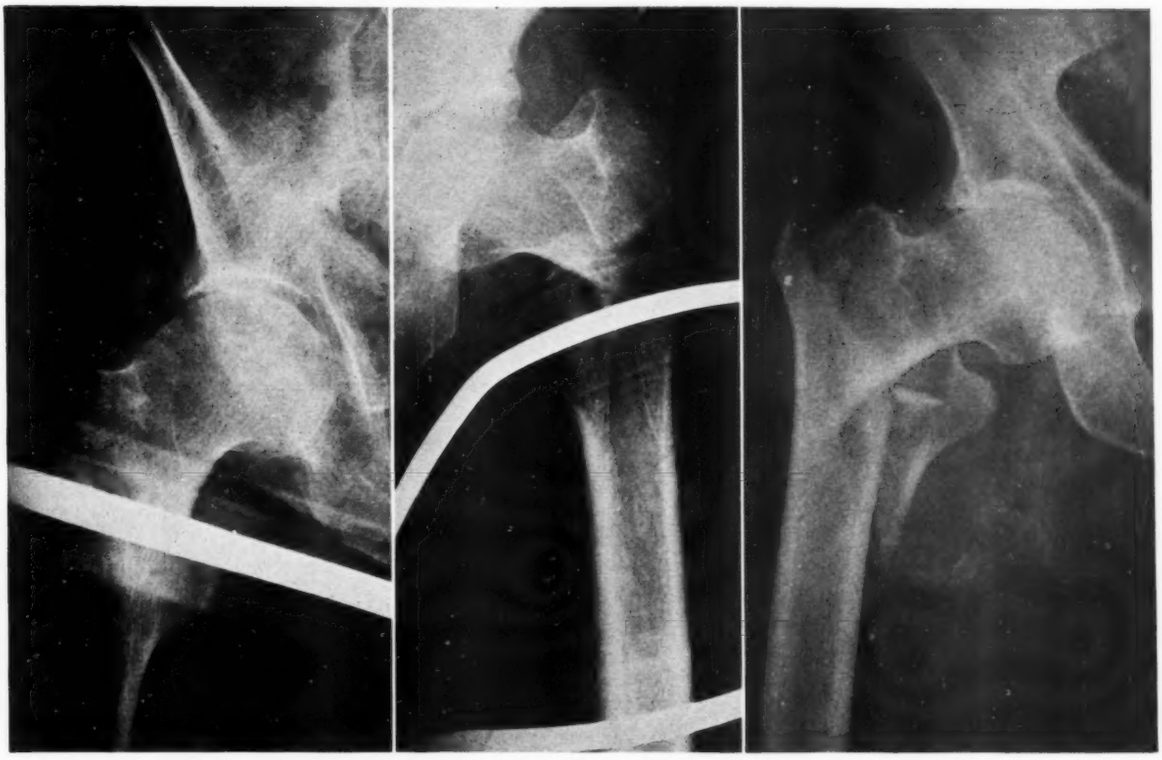
A vitallium® device for implementation of this thesis was described. It was stated that in a small series of cases "the holding power of the device over the period required for fracture healing had proved adequate." This statement was premature. Continued use proved the original device to be unreliable and prone to loosening of its "set screw" locking mechanism. (Fig. 1.) This defect was eradicated by eliminating the "set screw" in favor of an elastic "stop nut" similar to those used in airplane construction and with proved resistance to loosening strains. (Fig. 1.)

Unfortunately the original "set screw" models are still used in far greater numbers than the more dependable modified appliances. The primary purpose of this report is to paint the unreliability of the original "set screw" device in its true clinical colors, and to condemn it as unfit and unsafe for use in fixation at the hip. The dependability of the modified apparatus locked by an elastic "stop nut" will be tabulated, and the usefulness of secure adjustable internal fixation for the hip will be confirmed. (Fig. 2.)

INDICTMENT OF THE ORIGINAL "SET SCREW" DEVICE

The Inherent Fallibility of a "Set Screw" Lock. The surgeon, in applying the original "set screw" device, often overlooked a basic and essential mechanical principle, viz., that moving parts in order to remain securely locked by a "set screw" must fit together perfectly. An exact fit of fracture or osteotomy fragments usually is desirable, but not always essential. It is the two components of the fixation apparatus (nail and plate) that must fit perfectly. Unless the base of the nail finds an exact seat against the plate, the "set screw" cannot seat squarely. Tightening of the "set screw" then concentrates all compression at one bearing edge of its head so that very little vibration or unwinding strain is required for loosening.

Augmenting intangible elements of misapplication of such a device, the common denominator of postoperative mobility of the hip exerts repeated loosening stresses upon the



3A 3B 3C

FIG. 3. Classification of intertrochanteric fractures. A, Type I, undisplaced, often impacted, stable. B, Type II, displaced, intact lesser trochanter, stable when reduced and internally fixed. C, Type III, displaced and comminuted with loss of lesser trochanter buttress, unstable before and after fixation.

"set screw." Each motion into flexion of a right hip and extension of a left hip is a minute attempt to unwind the plate, and "set screw," from the nail.

Penalties Attending Original "Set Screw" Device. These accumulated slowly, but eventually reached alarming proportions. Loss of fixation due to loosening of the "set screw" must now be accepted as a risk in all cases. Silent development of a varus deformity at the fracture site results from this mishap. Notwithstanding all attempts to eliminate technical errors of application, this complication has been encountered with a frequency sufficient to condemn the original "set screw" model (Fig. 1) as unfit and unsafe for clinical use. (Table I.)

OTHER FACTORS CONCERNING LOSS OF FIXATION AND VARUS DEFORMITY

Type of Fracture. It appeared likely that continuing stresses and strains upon the fixation element would vary according to the nature of the fracture. Trochanteric fractures were therefore separated into three categories essentially indicative of their intrinsic stability prior to fixation. (Fig. 3.) Pure subtrochanteric fractures and high femoral osteotomies were also segregated. Analysis indicated that, regardless of other factors, some predisposition to loss of fixation by loosening of the "set screw" depended upon the intrinsic stability of the fracture to be stabilized. A complete absence of any effect from this factor was apparent in lesions treated by the modified "stop nut" device. (Table II.)

TABLE I
COMPARATIVE SECURITY OF FIXATION

Type of Fixation	Cases Treated	Lock Loosened	Per cent
Original "set screw" device	62	20	32.3
Modified "stop nut" device	50	0	0

It also appeared likely that, exclusive of other factors, the intrinsic stability of the frac-

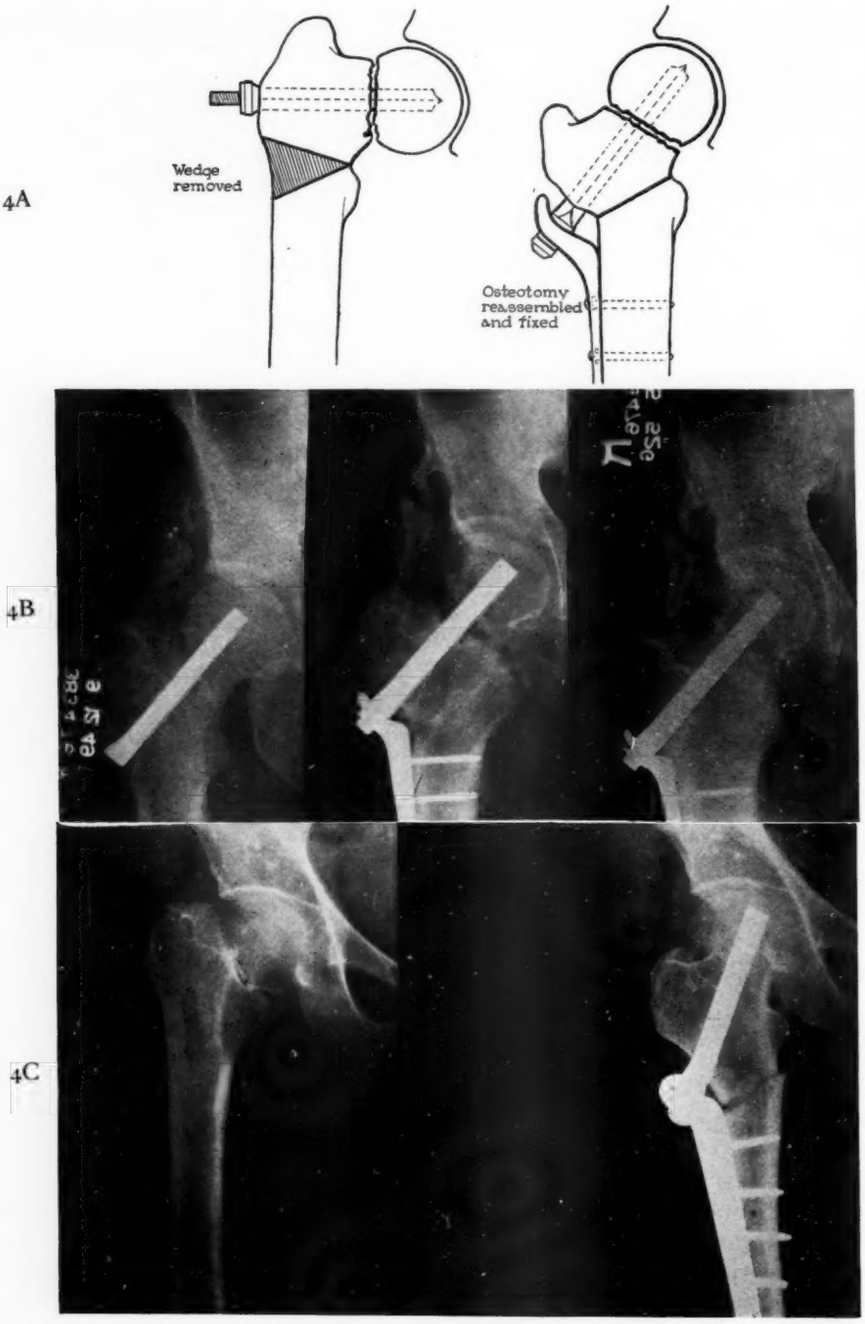


FIG. 4. A, adjustable fixation facilitates high femoral osteotomy. Left, the osteotomy is fashioned according to the dictates of the fracture. Right, secure fixation coincident with a good fit of the cut bone surfaces is available regardless of osteotomy angle. B, intertrochanteric wedge osteotomy. Left, non-union femoral neck fracture. Center, following osteotomy. Note apposition of cut bone surfaces. Right, final result. Hip motion and crutch walking continued throughout convalescence. C, primary subtrochanteric osteotomy for vertical subcapital fracture of femoral neck; immediately before and after fixation.

ture would have some bearing upon the degree of eventual deformity which followed loss of fixation. This supposition was confirmed. (Table III.)

Time of Disruption. It was speculated that in all categories of fractures the severity of the end deformity would increase in direct proportion to the speed with which loss of fixation took place. This proved to be the case. (Table IV.)

Analysis of the time element also illustrated with unequivocal clarity a point often unrecognized or overlooked in the management of the fractured hip, viz., that roentgen evidence at best is a poor measure of bone healing. Almost without exception the fractures which lost fixation after three months and assumed a subsequent varus deformity had, prior to this mishap, appeared united by roentgenogram.

TABLE II
RELATION OF FRACTURE TYPE TO LOSS OF FIXATION

Type of Fracture	"Set Screw" Device			"Stop Nut" Device	
	Cases	Loosened	Per cent	Cases	Loosened
Intertrochanteric					
Type I	11	2	18.2	11	0
Type II	17	5	29.4	11	0
Type III	26	12	46.1	23	0*
Subtrochanteric	8	1	12.5	5	0
Totals	62	20	32.3	50	0

*Loss of fixation occurred in two type III intertrochanteric fractures. The stud (Fig. 1), having a torque strain test of 150 pounds per square inch, was sheared from the nail. It was indeterminate whether this mishap resulted from faulty application, fatigue strain or defective fixation material. Presently the stud has been enlarged and its test strain increased to more than 250 pounds.

Osteotomy of the Femur. Adjustable internal fixation has particular advantages in the management of high femoral osteotomies. Both operation and after-care are simplified. After removal of an appropriate wedge of bone from the inter- or subtrochanteric region of the femur an adjustable fixation element then provides both remaining local prerequisites to a happy result, viz., accurate apposition of the cut bone surfaces coincident with fixation which permits ambulation on crutches and continuance of limb function throughout the healing period. (Fig. 4.) Only thirteen osteotomies were treated in this way, but the results were uniformly satisfactory. All healed rapidly and well. All fixations remained secure.

TABLE III
RELATION OF FRACTURE TYPE TO END DEFORMITY VARUS

Fracture	None	Minor (Few°)	Moderate (110°)	Severe (90°)
Intertrochanteric				
Type I	1	1	0	0
Type II	1	1	1	2
Type III	2	2	1	7*
Subtrochanteric	0	0	0	1*

* Four patients required reoperation.

TABLE IV
RELATION OF DISRUPTION TIME TO END DEFORMITY VARUS

Months	None	Minor (Few°)	Moderate (110°)	Severe (90°)
0–1	..	..	..	5
1–2	..	1	1	4
3–5	..	2	1	..
6 and over	3	2	..	1

SUMMARY

The usefulness of adjustable internal fixation for the hip previously postulated has been confirmed by clinical test. The device originally described was imperfect in design and should be discarded. After many and continuing modifications current models approach maximum efficiency and dependability. They are not perfect, nor will any implement for the internal fixation of fractures approach perfection until the optimum in chemical inertness and metallurgic toughness has been combined in the materials used, the optimum in mechanical design attained, and last but far from least, they are properly applied by the surgeon.

CONCLUSIONS

The adjustable hip fixation device locked by a "set screw" is unfit and unsafe for clinical use, and should be discarded.

A modified device locked by an elastic "stop nut" has proved dependable, and is a useful instrument for the stabilization of certain lesions at the hip.

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Use of the Tomogram after Attempted Joint Fusion

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A TOMOGRAM is defined as an x-ray film of a selected plane in the body at any desired level undisturbed by shadows of other tissues above or below this level. This was first used by Sir John Tomes,[14] an English dentist, in 1889 and now is also known as laminagram or

FIG. 1. Case IV. Preoperative roentgenogram July 21, 1949, showing narrowing of left hip joint, partial fragmentation of head of the femur and absorptive changes.

planigram which furnishes shadows on the film to help determine osteogenesis and bony union across a joint after attempted operative fusion.

Omitting technical details we wish to demonstrate this neglected means of proving final arthrodesis of a joint after disease or operation.[9,10] Such determination may have both clinical and medicolegal significance. An attempt by orthodox roentgenologic examination in two planes may give false information and lead to too early use of a joint, resulting in breaking down of an incomplete fusion and a reversion of the joint to its previous painful or reduced usefulness.

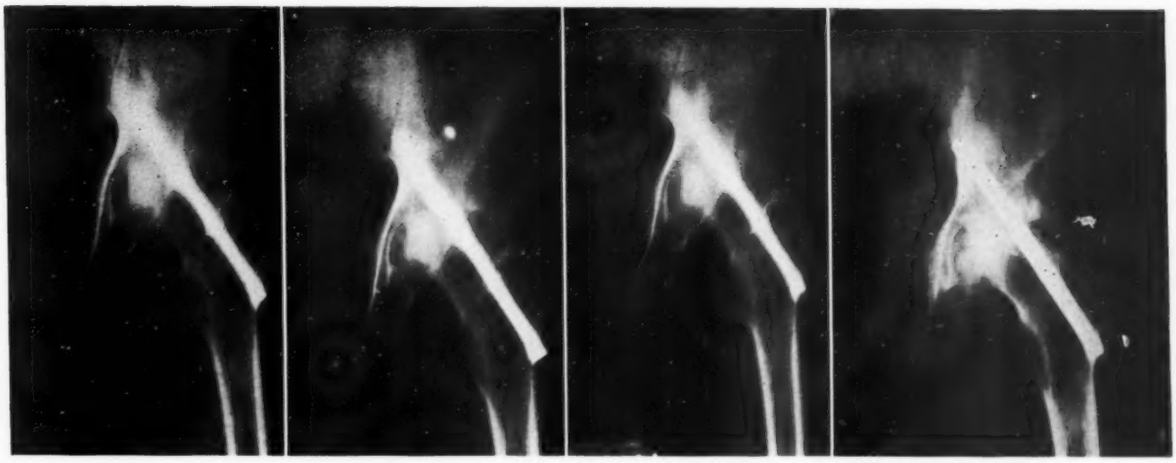
CASE REPORTS

CASE 1. A sixty-one year old shop foreman fell on a floor in June, 1940. In September, 1941, an intervertebral disc was removed elsewhere without relief of pain in his left hip. In April, 1942, a second surgeon recognized fracture of the head of the femur and inserted an overlong Smith-Petersen nail through the neck and head of the left femur into the ilium. When examined eleven months later by Dr. Speed the patient was still limping on a painful left hip in which there was some motion with no roentgenologic evidence of fusion. The nail was bent, proving that it was carrying his weight. On April 21, 1943, the nail was removed and an autogenous bone graft inserted through the neck and head of the femur into the ilium, after the acetabulum and comminuted head of the femur had been denuded of all cartilage. Bone chips were placed about the joint and a double plaster spica was applied. Four months later roentgenograms showed an apparently firm, bony ankylosis. He became ambulatory on crutches without weight-bearing on the left leg, but a month later roentgenograms showed the bone transplant had been fractured. The position of the femur and pelvis remained unchanged. Two months later pain ceased. He was fitted with a walking splint and fifteen months after operation bony fusion was not yet definitely established on ordinary roentgenograms.

This condition persisted but he returned to light work. Twenty-eight months after operation a final roentgenogram did not assure us of complete hip joint fusion.

Such a long-postponed result after fracture of the head of the femur lead to later adoption of the tomogram for study of all attempted joint fusions.

Regardless of the operative technic used to get hip joint arthrodesis there is no doubt that individual variation exists in the time required for postoperative immobilization and abstinence from active use and, finally, weight-bearing on the leg. In combined external and



2A 2B 2C 2D

FIG. 2. Same case. A, postoperative tomogram October 17, 1949, at depth 8 cm. showing position of nail in ilium, abduction of femur and bony fusion across the old hip joint at this level. B, tomogram at 9 cm. showing continued evidence of position and bony fusion previously described. C, tomogram at 10.5 cm. showing corroborative evidence of fusion at this depth. D, tomogram at 11 cm. Note the full shadow of the iliac flap turned down. Solid union.

internal fusion of the hip, which we choose for illustration, the head of the femur, after freeing and dislocation, is denuded of cartilage and freshened. The acetabulum is likewise treated and, after replacement of the head of the femur into the modified articulation, bone chips from the ilium may be placed about the joint following the turning down of a strip of bone from the surface of the ilium into the split trochanter of the femur. An overlong Smith-Petersen nail is inserted through the neck and head of the femur and on through the acetabulum into the ilium, after selecting the exact degree of abduction and flexion demanded by the specific patient. It is an easily inserted and strong fixation agent. A suitably sized autogenous bone transplant is difficult to obtain, requires longer operative time and may break during its insertion. Thus the femur is not weakened by the loss locally of a shaft or trochanteric graft. If the hip joint is already partially ankylosed, a transplant from the iliac crest may be inserted into an excavated slot across the joint area. Results in this type of fusion are not invariably certain, but it is a quicker operation and the patient may tolerate it better.

After firm immobilization of the hip in a plaster spica for from fourteen to sixteen weeks the best criterion for satisfactory fusion and permission for beginning weight-bearing may be decided by a tomogram showing bony union clear through the contacting denuded joint surfaces. The surgeon can use tomography in his roentgenologic examination of the hip or any joint to insure his result, which may involve a compensation or medicolegal dispute. We have used this method for years, but it has only recently sprung into some popularity in thoracic and spinal surgery.[8,11] It may be used on any joint for various purposes of diagnosis in disease, after injury, search for sequestra or foreign bodies, study of the osteogenetic quality of autogenous bone transplants, delayed or non-union after fracture, or final results after a wide range of operations.

CASE II. A twenty-six year old male clerk had left hip joint pain, a limp and 1 inch shortening on September 23, 1946, five years after his pelvis was caught between a truck and platform. Roentgenograms showed flattening of the head of the left femur and coxa vara with roughening of the acetabulum and narrowing of the joint space. Fusion of the hip joint was attempted by removing the articular cartilage from the head of the femur and the insertion of an overlong nail into the ilium plus packed-in bone chips. The head of the femur could not be completely dislocated and no bony flap from the ilium was used. After a fall a year later he again had hip pain but the usual roentgenograms showed no change in position of the nail or lack of bony union. Pain persisted. Three years after operation a tomogram revealed lack of bony fusion at the hip. He was recasted and made final recovery one year later.

CASE III. A sixty-eight year old retired insurance broker was seen February 18, 1949, with

FIG. 3. Same case. Postoperative roentgenogram March 15, 1950, showing the continued fused condition and bone formation eight months after operation, patient walking on hip.

a dislocated left tabetic hip joint. Both new bone deposition and absorptive changes in the head of the femur and acetabulum were present. Because of his pain and disability the joint was fused on March 24, 1949, employing an overlong nail and iliac bone flap. A cast was worn for five months, and six months after operation a tomogram showed a satisfying bridge of bone from the ilium to the greater trochanter of the femur but no bony fusion across the joint and recurring dislocation of the hip. He suffered from psoriasis and cystitis. It was necessary to remove the nail from the femur followed by curettage and drainage of the joint. Failure of fusion was acknowledged but he was able to walk with the aid of a cane. He was confined to the house for five years after operation. In this instance the tomogram was of great help in establishing a prognosis.

CASE IV. A fifty-seven year old lawyer was first seen August 21, 1949. He complained of severe left hip pain of eight months' duration with some atrophy of the thigh and 1 cm. shortening of the leg. Roentgenologic examination proved advanced morbus coxae senilis. At operaton on August 26, 1949, fixation of the hip by a long nail, bone chips and with ilium flap added was performed. The cast was removed October 17, 1949, and a tomogram was made. This showed full new bone formation in the old joint space and unchanged position of the nail. The patient made a slow recovery and left the hospital on November 11, 1949, using crutches which were soon discarded. Satisfactory fusion followed as proved by tomogram. (Figs. 1–3.)

With final postoperative determination of bony arthrodesis of a hip a surgeon may confidently permit his patient to return to weight-bearing and occupation and terminate a continuing disability. Thus a final loss of function after injury can be established.

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Management of Complicated Tibial Fractures

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COMPLICATED fractures of the tibia associated with fractures of the fibula have always taxed the ingenuity of the surgeon dealing with traumatic surgery in the past, and will probably continue to do so in the future. The methods of handling them have been varied. Closed reduction in many instances has given a good result. Skeletal traction is often the solution, but here one is faced with a rather serious economic problem; and in the smaller community hospitals with rapidly changing personnel it is difficult to instruct the nursing staff in the proper management of balanced traction and suspension. Double pins and plaster, plates and/or screws, and intramedullary fixation all undoubtedly have their place. Neither of the methods to be described is claimed to be original, but they are merely presented as two more adjuncts in the surgeon's armamentarium.

First Method. During World War II the author had occasion to manage a seriously comminuted open fracture of the tibia, associated with considerable loss of substance, with a closed fracture of the fibula. It was impossible to maintain length in plaster, and skeletal traction was precluded because of the military situation. In trying to arrive at some satisfactory method in handling this case so that length could be maintained until definitive bone grafting of the tibia could be carried out, it was recalled that fractures of the shaft of the tibia alone with an intact fibula rarely showed overriding. Therefore, it was decided to create the fracture of the shaft of the tibia and fibula into a fracture of the tibia alone by internal splinting of the fibula. This was done accordingly, and length was maintained satisfactorily until such time as definitive surgery could be carried out. Since that time the author has had occasion to carry out this operative procedure in three cases.

CASE I. This thirty-five year old man was first seen thirty-six hours after having been struck by an automobile. On examination he presented a dirty open wound of the anterior tibial region with a severely comminuted fracture of the tibia. In addition, there was a closed fracture of the fibula. Because of the contaminated nature of the tibial wound, it was believed that any attempt at fixation of this bone would be fraught with danger. Accordingly, simple débridement of the tibial wound was carried out with no attempt to replace the fragments in any sort of anatomic position. The wound was left open. Through a clean incision the fracture of the fibula was approached and immobilized by means of plate and screws. Secondary closure of the open tibial wound was carried out three days later. The man made an uneventful recovery, and at the end of eight months had solid bony union with a normal-appearing leg. (Fig. 1A and B.)

CASE II. This twenty-five year old man had had his right lower leg run over by a heavy dump truck. He was not seen in consultation until forty-eight hours after the injury, at which time the wound had not been débrided. He presented a dirty, contaminated, open wound of the lower third of the tibia with a comminuted fracture at this level, as well as a closed fracture of the fibula at a slightly higher level. Skeletal traction through the os calcis failed to yield satisfactory position, and accordingly one week after the injury the fibula was attacked directly through a clean incision and a plate and screws applied. Again this man made a completely uneventful recovery, and had solid bony union at the end of eight months.

CASE III. A thirty year old professional skier sustained a severely comminuted fracture of the tibia, and a fracture of the fibula as well. At open operation it was impossible to stabilize the tibia long enough to apply any internal fixation. Accordingly, the fibula was exposed and immobilized by a curved, intramedullary nail. This gave sufficient stability so that the tibial fracture could again be attacked, and the various fragments held in place by means of several screws. (Fig. 2A and B.) If I had been employing the second method at the time of this accident, I think that Parham bands would probably have been used in place of the screws.

Comments. On occasion, by conversion of a fracture of the tibia and fibula into a fracture of the tibia alone by internal splinting of the fibula, one may be able to solve a rather difficult fracture problem. In three of these four

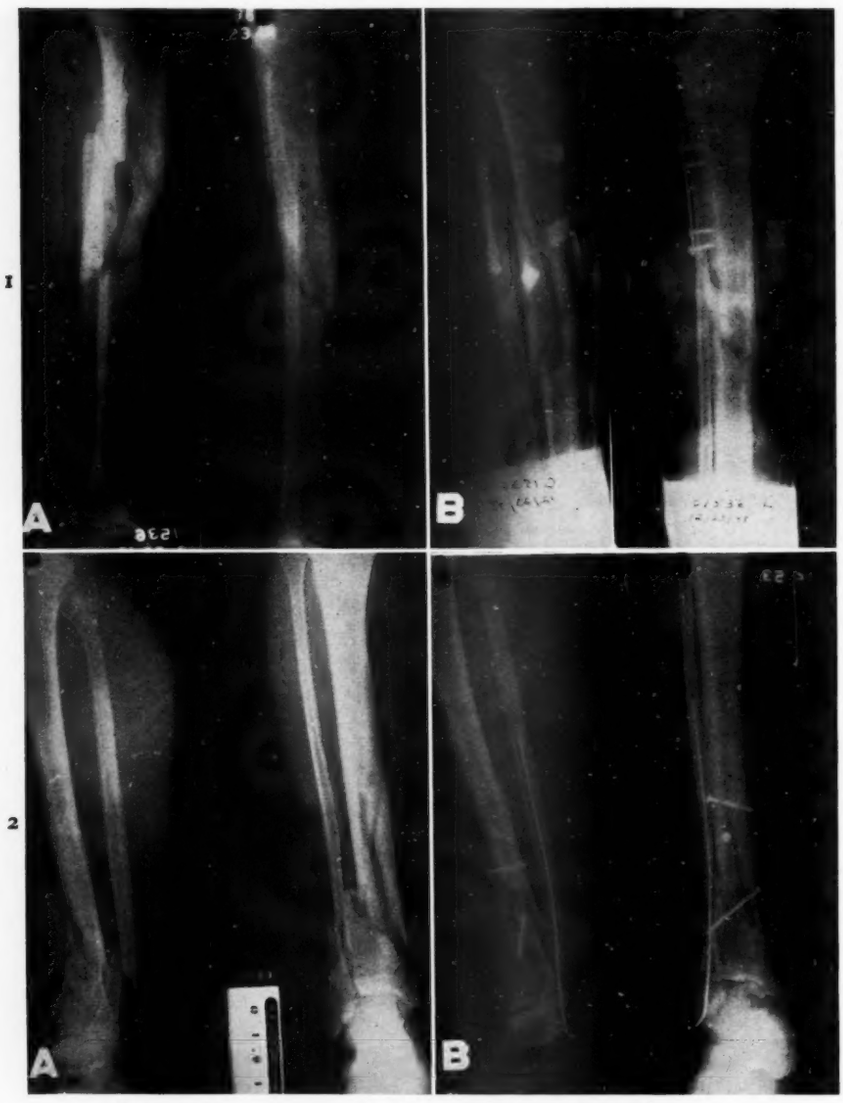

FIG. 1. Case I. A, preoperative x-ray; B, postoperative x-ray.

FIG. 2. Case III. A, preoperative x-ray; B, postoperative x-ray.

cases, contamination of the tibial wound precluded any therapy by means of a direct attack on this bone, and the internal splinting of the fibula resulted in good union of the tibia, or, as in the military case, at least held the fragments in relative position until bone grafting could occur. In Case III it was only after internal splinting of the fibula that the tibial fragments could be manipulated into proper position to maintain them with any reasonable degree of stability. It is realized that there is a very limited place for this method of handling fractures of the tibia, but the author believes there are occasions when it can be extremely useful.

Second Method. Until February, 1953, the author believed, as I am sure the majority of other men doing fracture surgery did, that the use of the Parham band was to be mentioned only to be condemned. At this time a paper was presented before the Committee on Trauma of the American College of Surgeons in Boston by Dr. George Shedd of North Conway, New Hampshire, on the use of the Parham band in the management of ski fractures of the tibia. I was so impressed by the excellence of his results that I promptly returned home and purchased a set of Parham bands. Dr. Shedd stressed three points: first, that the bands should be placed subperiosteally; second, that they should not be placed

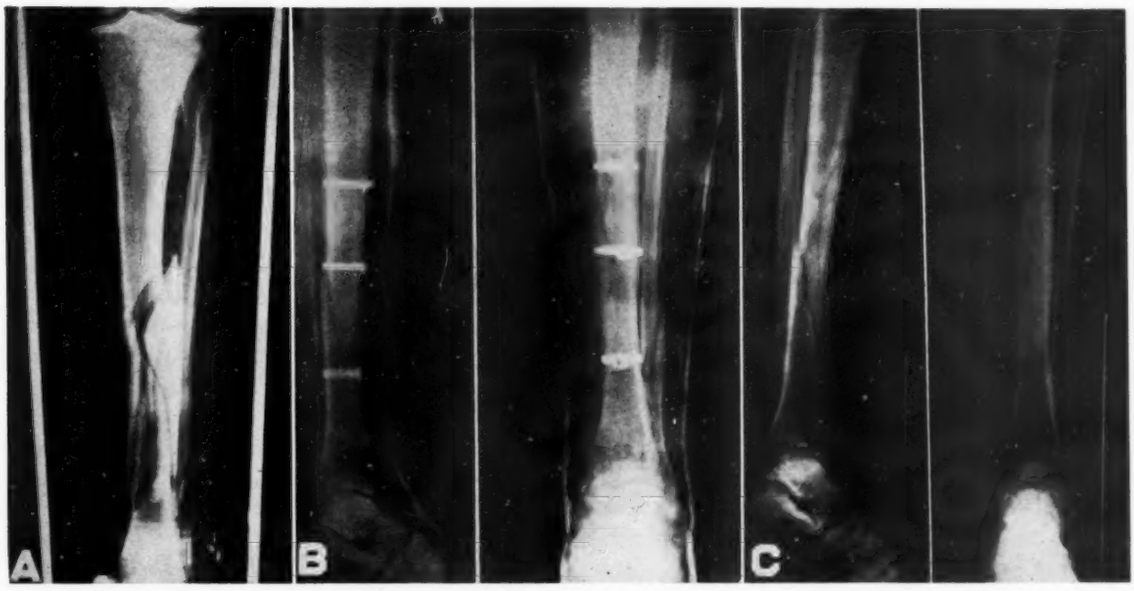

FIG. 3A to C. Case IV. A, preoperative x-ray; B, lateral and antero-posterior views, postoperatively; C, lateral and antero-posterior views, postoperatively.

too tightly; and third, that they should not be left in too long.

In the past eighteen months we have had occasion to use Parham bands on fourteen different patients, and to date we have been delighted with the end result.

CASE IV. This twenty-one year old college student was skiing and fell, sustaining a twisting injury and an open, comminuted fracture of the tibia, and a double fracture of the fibula. Primary débridement of the wound was carried out. It was obvious that no form of plate would be able to hold all of the various fragments. It also seemed likely that any form of intramedullary fixation would not result in a stable fixation. Accordingly, it was determined to try Parham bands and three of them were applied. The patient made a very gratifying recovery. The bands were removed at eight weeks, at which time he had clinically solid union. He was fitted with a long leg brace at twelve weeks, and this was completely discarded at four months. Six months postoperatively he had a completely normal-functioning extremity. (Fig. 3A to C.)

CASE V. A twenty year old man sustained a similar injury while skiing, within twenty-four hours of Case IV. The only difference was that this was a closed rather than an open fracture. Again his postoperative course was extremely satisfactory with clinical solid union at eight weeks, and x-ray evidence of solid union at four months.

CASE VI. A young friar fell while skiing, sustaining a relatively simple type of spiral fracture of the tibia and fibula. There is no question but what this case might have been well managed by almost any of the accepted methods. It might be mentioned that cast fixation was unsuccessful and resulted in overriding. It was extremely important that this young man be returned to his institution as rapidly as possible, and accordingly it was elected to apply Parham bands. By so doing, the young man was released from the hospital within five days of operation, and was rehospitalized for a period of forty-eight hours at the time of removal of the bands. Again a complete recovery was made, and he was on full weight-bearing at twelve weeks.

The final case presents the use of the bands in combination with intramedullary nailing. This young man suffered from severe neuromuscular dystrophy, but in spite of this was an ardent skier. He sustained a fracture of the shaft of his tibia with a butterfly fragment. Attempts at closed reduction were unsuccessful. It was believed extremely important to mobilize this man because of his neuromuscular difficulty, and accordingly open reduction was carried out, a curved Rush nail was inserted into the tibia and the butterfly fragment maintained by means of two Parham bands.

As mentioned previously, we have had occasion to use this procedure on fourteen patients during the last eighteen months. Perhaps some of them could have been managed perfectly well by other methods, but we were anxious to try out the technic and see what the pitfalls were. To date we have been completely satisfied and plan to continue the procedure. We have

expanded it a little and used it in two cases of non-union in which we have employed a sliding bone graft, using the bands to attach the bone graft to the non-union site. In both cases union of the graft to the parent bone and solid union of the non-union have taken place.

Comments. We believe that the reasons the Parham band went into disrepute were probably threefold. In the first place, at the time that they were first being used extensively, our metals were definitely inferior and undoubtedly caused local reaction. Secondly, the bands were applied too tightly, causing local death of bone beneath the band. Thirdly, the bands were left on far too long, in many cases being left on indefinitely or until the bone fractured beneath the band. We believe that if one follows the precepts laid down by Dr. Shedd—careful application of the band subperiosteally, not applying the bands too tightly and removing them at eight weeks—none of the complications previously encountered with the use of the band will be evident. The apparatus necessary for its use is extremely simple: three or four offset wire passers of various sizes, a Parham band applicator and the bands themselves are all that are needed besides the ordinary bone instrument armamentarium. In applying the bands certain precautions must be taken. The passer must be inserted subperiosteally. Care must be taken that muscle and fascia are not included and pulled through at the time of drawing the Parham band behind the tibia. The band is tightened until the marrow begins to exude along the fracture lines. It is then released a quarter of a turn. Again care must be taken in bending the band back to lock it, since on one or two occasions we have cut through the eye of the band.

We have been impressed by several factors in the use of the band. The first is the almost complete absence of any callus formation, the fracture healing by creeping substitution. This is probably attributable to the fact that only a minimal amount of subperiosteal stripping is performed. We believe it is also probably due to the fact that by compression of the fractures we have exerted that type of compression that has been demonstrated by both Charnley and Eggers to be a factor in early bone healing. All too frequently with screw fixation or plate and screw fixation the fragments are held apart and one does not obtain the proper compression necessary for early union.

CONCLUSIONS

The author has presented two little publicized methods of managing fractures of the shaft of the tibia and fibula. No originality is claimed for them nor is it believed that they should be used to the exclusion of the other established methods of managing these complicated fractures. However, we do believe that there are certain instances in which internal splinting of the fibula may solve an extremely difficult problem of management of the comminuted open fracture of the tibia. We also believe that to date, in our hands, the use of the Parham band has resulted in much earlier bony union than any other method previously employed by us.

Clinical Significance of a Classification of Epiphyseal Injuries at the Ankle

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CLINICIANS have long been aware of the possibility of growth disturbance following an epiphyseal injury, but the probability of this has varied greatly according to the epiphysis studied. Investigators of epiphyseal injuries, with the exception of Aitken,[1] Bishop[4] and McFarland,[18] have grouped fractures and separations of the distal tibial and fibular epiphyses with epiphyseal injuries from other parts of the body in their reports. The inclusion of this material in general reports on epiphyseal injuries has been extremely useful in outlining the broader aspects of epiphyseal injury and repair. Because injuries from various parts of the body with different causative mechanisms and dissimilar anatomic considerations were grouped together, however, it is believed that certain points of definite practical value were overlooked. Attention was therefore directed in this study specifically to injuries of the distal tibial and fibular epiphyses with the hope that an analysis and careful follow-up of a larger series of cases of this specific injury might better explain their pathogenesis and prognosis, and that the indications for remanipulation and operative intervention could be clarified.

TABLE I

PER CENT OF EPIPHYSEAL INJURIES IN LOWER EXTREMITY (EXCLUDING HIP) OCCURING AT ANKLE IN OTHER SERIES

Bergenfelt	97%	Eliason	57%
Bisgard	74%	Lipschultz	95%
Compere	69%	M. K. Smith	100%

Fifty-four fractures and separations of the distal tibial and fibular epiphyses have been seen in thirty years of orthopedic practice at the Willis C. Campbell Clinic from January, 1923 to January, 1953. During this period of time a total of 1,413 fractures and epiphyseal injuries of the ankle was seen. The fifty-four epiphyseal injuries represented 4 per cent of the 1,413 ankle injuries.

Epiphyseal injuries in the lower extremity, exclusive of slipping of the capital femoral epiphysis, included 103 cases. In addition to the distal tibial and fibular epiphyseal injuries, thirty-eight injuries involving the distal femoral epiphyses and nine injuries involving the upper tibial epiphyses were seen. This preponderance of injuries to the lower tibial and fibular epiphyses was also found by Bergenfeldt,[15] Bisgard,[3] Compere,[8] Eliason and Ferguson,[10] Lipschultz,[17] and Smith[22] (Table I).

TABLE II

CLASSIFICATION OF OUR INJURIES*

Type of Injury	Campbell Clinic		Bishop[4]	
	No.	%	No.	%
Abduction	20	37	4	12.5
External rotation	11	20	6	18.7
Plantar flexion	6	11	..	....
Axial compression	2	3.7	4	12.5
Direct violence	1	1.9	1	3.2
Adduction	14	26	17	53.1
Total	54		32	

* According to Ashhurst and Bromer.[2]

Poland,[21] who in 1898 made the first extensive study of epiphyseal injuries, believed that the distal tibial and fibular epiphyseal fractures and separations could not be classified on a mechanistic basis. A review of our cases, however, revealed that anatomically similar fractures and/or separations had been caused by predictably similar injuries, therefore, like Bishop,[4] we prefer to attempt classification according to the general outlines of Ashhurst and Bromer.[2] According to this classification

we had twenty injuries showing lateral displacement of the distal tibial and fibular epiphyses (the abduction type); twenty injuries showing a posterior displacement of the tibial epiphysis included eleven of the external rotation type, six caused by forcible plantar flexion, and three due to axial compression or direct violence; fourteen injuries showing varying degrees of medial displacement were classified as adduction injuries. Table II reveals the relative incidence of these classes of injuries as compared to the series of Bishop.[4]

TABLE III
FOLLOW-UP OF CASES*

Type	Cases Seen	No. Followed up	Per cent Followed up
Abduction	20	14	70%
External rotation	11	5	45%
Plantar flexion	6	2	33%
Axial compression and direct violence	3	2	66%
Adduction	14	10	71%
Total	54	33	61%

* Average follow-up: 9.6 years. Median age at follow-up: 19 years.

Follow-up of our fifty-four cases was accomplished in thirty-three instances, twenty-nine follow-ups having been carried out in this Clinic with physical examination and x-rays and four follow-ups made through correspondence; one of these cases was examined and x-rayed by a local physician. Five cases which were not followed past the age of epiphyseal closure were nevertheless followed for a minimum of four years. Table III indicates our follow-up for each of the major classified groups. While Aitken[1] followed his twenty-one cases from two to ten years, McFarland[18] stated no follow-up in his series and Bishop[4] admittedly had no follow-up of his cases.

All twenty of these injuries with lateral displacement of the epiphyseal fragment were third degree, as defined by Ashhurst and Bromer,[2] the entire tibial epiphysis moving as an intact unit with an accompanying lateral metaphyseal fragment in most cases. This is the type I of Aitken.[1] Figure 1A demonstrates the x-ray appearance of this injury.

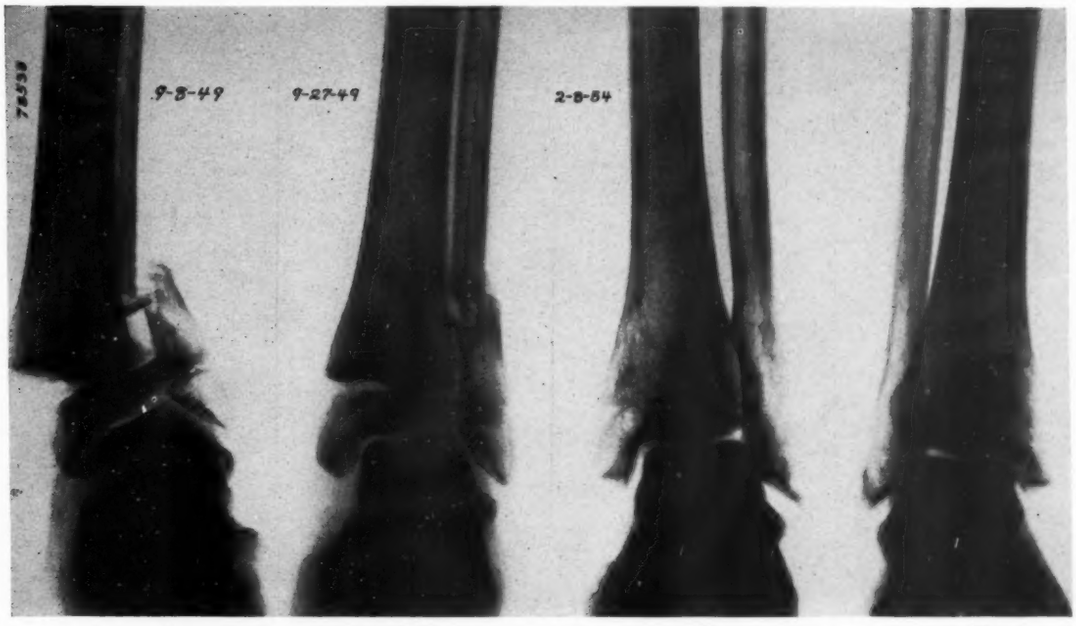
Five of the twenty cases sustained injuries below the age of twelve but none below the age of eight. There were seventeen males and three females. (Table IV.) All but three injuries were sustained in a vehicle accident or while the patient was engaged in a contact sport. In only two cases was an indirect type of violence in doubt as the cause of injury. Lateral displacement of the tibial epiphysis was seen in all cases except one. This displacement varied from 10 to 66 per cent of the width of the metaphysis. (Throughout our discussion we have recorded the distance which the distal fragment is displaced as a percentage of the total epiphyseal width and we have likewise recorded the size of the adherent metaphyseal fragment according to the percentage which it represents of the total metaphyseal width.) In all but two of these cases a lateral metaphyseal fragment accompanied the tibial epiphysis, varying in size from a slip of bone representing approximately 5 per cent up to a triangular wedge of bone representing 60 per cent of the metaphyseal width.

TABLE IV
ABDUCTION INJURIES IN TWENTY CASES (37% OF SERIES)

Median age	14
Average displacement	26%
Average size metaphyseal fragment	23%
Average time non-weight-bearing	5½ weeks
Cases followed	14 (70%)
Average follow-up	8.5 years
Age at time of follow-up	13 to 31 years

Manipulation under general anesthesia was carried out the day of or the day following injury in all but two cases which were done on the third and fourth days following injury. The latter case represented an open reduction using two vitallium® screws with excellent postoperative position of the fragment but with drainage from the wound site for eight weeks. Position after manipulation was considered in good functional alignment in all except eight cases. Six of these cases were among the fourteen followed up, and in these six a spontaneous correction of the valgus tilt of the ankle mortise was demonstrated in follow-up x-rays. Both boot and long leg casts were used following manipulation for periods varying from four to eight weeks, and the duration of non-weight-bearing varied from three to twelve weeks.

Shortening developed in two patients. One was a twelve and a half year old boy who developed ¼ inch shortening at the time of



1A 1B 1C 1D

FIG. 1. Abduction fracture separation of distal tibial epiphysis. A, before reduction. B, postreduction with residual valgus tilt of ankle mortise. C, same ankle almost five years later showing spontaneous correction of the valgus tilt. D, opposite ankle at same time as (C).

injury without a tilt of his ankle mortise. The other, a boy of thirteen and a third years, developed shortening of 1⅛ inches following injury. Since he corrected 12 degrees of relative valgus tilt of the ankle mortise while developing this shortening, it was believed that the shortening was due to a definite premature fusion of the upper tibial epiphysis which resulted in a genu recurvatum. These two cases of shortening are the only instances in which measurable shortening was found in all classes of injury, except for the severe adduction deformities in which incapacitating varus tilt developed as well. There is no evidence that the degree of displacement, adequacy of reduction or duration of non-weight-bearing had any influence on the outcome of these abduction cases.

TABLE V
EXTERNAL ROTATION INJURIES IN ELEVEN CASES (20% OF SERIES)

Median age	14
Average displacement	43%
Average size metaphyseal fragment	32.5%
Average time non-weight-bearing	6½ weeks
Cases followed	5 (45%)
Average follow-up	10 years (5 to 14)
Age at time of follow-up	14 to 31 years (24.5)

External rotation epiphyseal fracture separations (Table V) could in all cases be recognized by the tendency toward a posterior displacement of the entire tibial epiphysis (third degree according to Ashhurst and Bromer[2]) accompanied by a fracture of the fibula. (Fig. 2.)

Only one patient was younger than twelve years, having been eight years, ten months old at the time of injury. All were males, and in every case but one an indirect external rotatory force sustained in a vehicle accident or while engaged in contact sports was the cause of the injury. Displacement posteriorly of the tibial epiphysis varied from 10 to 90 per cent of the metaphyseal width and was accompanied by a posterior metaphyseal triangular fragment ranging between 10 and 50 per cent of the width of the metaphysis itself.

Manipulation of the fracture separation under general anesthesia was attempted the day of or the day following injury in all cases. Duration in plaster and duration of non-weight-bearing each varied from three to ten weeks, good functional position having been accomplished in all but one case. This was the case of an eight year old who had originally been manipulated by the referring physician, was remanipulated here, sustained a skin slough with drainage from the ankle for some weeks

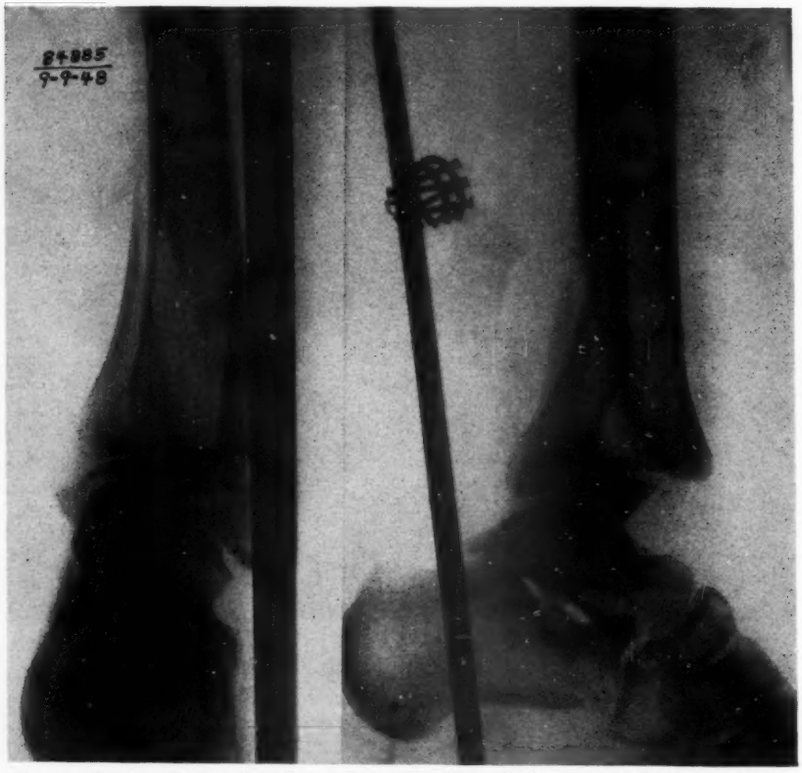


FIG. 2. External rotation fracture separation of the distal tibial epiphysis. Anteroposterior and lateral x-rays before reduction.

and had 10 degrees of valgus tilt of the ankle mortise noted by x-ray following our manipulation. Follow-up of this case five years later revealed both ankle mortises in 3 degrees of valgus, representing a 7 degree improvement by the injured ankle with symmetry restored.

TABLE VI
SPONTANEOUS CORRECTION OF MORTISE TILT

Type	Age (yr.)	Residual Tilt (degrees)	Age Seen (yr.)	Amount Corrected
External rotation	9	7	14	Full
Abduction	13½	12	18	Full
Abduction	14	7	25	Full
Abduction	8¼	7	13	Full
Abduction	15	5	18	−3°
Abduction	14	7	18	Full
Abduction	10¼	4	14.3	Full

This patient was among the five in this group who had follow-up examinations; in none of these was any deformity noted. One patient in this group had an open reduction fixed with two stainless steel screws and an excellent postoperative position of the fragment, but no follow-up was obtained.

Nine cases in the abduction and external rotation type of injuries did not have entirely satisfactory position following the initial manipulation. Seven of these nine cases were followed in this study and Table VI summarizes the spontaneous correction of valgus ankle mortise tilt observed in these seven cases. Figures 1B and C show the improvement in tilt of the mortise which growth has accomplished. In the seven cases showing this phenomenon it will be noticed that the maximal improvement in mortise tilt was 12 degrees occurring over a period of four and two-thirds years until the patient was eighteen years of age. The average

TABLE VII
PLANTAR FLEXION AND COMPRESSION INJURIES IN NINE CASES (16.5% OF SERIES)*

Median age	13½
Average displacement	13.5%
Average time non-weight-bearing	4.3 weeks
Cases followed	4 (44%)
Average follow-up	10 years
Ages at time of follow-up	16 to 38

* One case of axial compression showed fracture through tibial epiphysis, second degree injury.

improvement for the group was 6 degrees and in all cases but one the tilt was identical to that of the opposite ankle when measured on follow-up x-ray examination, indicating that symmetry had been restored.

Ashhurst and Bromer,[2] in classifying ankle injuries, include only one case presumed to be due to forced plantar flexion in a neutral saggital plane. They believe that this injury was due to minimal violence and in our series of six cases of plantar flexion injuries this is suggested, since no fracture of the fibula accompanies the posterior displacement which the entire tibial epiphysis undergoes as a single fragment. (Table VII.) This group included four males and two females all between the ages of eleven and a half and fourteen years; all gave a history of forced plantar flexion of the foot due to an indirect type of violence and the posterior slip of the tibial epiphysis varied up to 25 per cent of the metaphyseal width. In all but one case it was accompanied by a posterior metaphyseal triangular fragment much as in the case of the external rotational injury. In this group the largest fragment represented 40 per cent of the metaphyseal width. Both the distance of slip and the size of the metaphyseal fragment thus was smaller in this group than in the case of the external rotational injuries. The acute injuries were reduced the day of or the day following the accident under general anesthesia, and reduction was functionally adequate in all cases except one. This case was one of the two followed up and no clinical or x-ray deformity was found in either. Duration in plaster varied from zero to six weeks as did duration of non-weight-bearing.

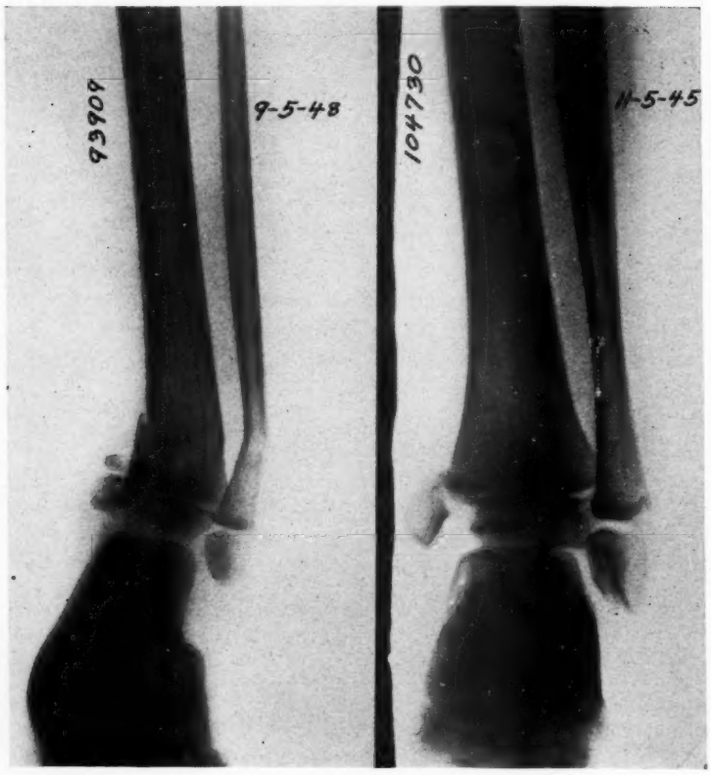
Three additional cases showed a tendency toward posterior displacement. They included two cases of axial compression and one case of direct violence; the ages ranged from eleven and a half to fourteen years. There were two males and one female, and the mechanism of injury was an automobile accident in one, a fall from a tree in the second and a direct crush in the case of direct violence. One of the axial compression cases, age fourteen, showed a 30 per cent posterior slip with a 50 per cent posterior metaphyseal fragment and a fracture through the tibial epiphysis centrally; adequate reduction was performed the same day under pentothal anesthesia. This case is the only instance of fracture through the epiphysis (second degree according to Ashhurst and Bromer[2]) except in the adduction group, and in light of our subsequent discussion it is interesting to note that this was a compression injury. The other case of axial compression showed only an anterior separation of the tibial epiphysis with negative follow-up examination at the age of sixteen years. In the case suffering direct violence a posterior position of the tibial epiphysis on the metaphysis, demonstrable one year after injury at age of twelve and a half years, was not seen on follow-up examination at eighteen and a half years.

ADDUCTION INJURIES

Of the fourteen injuries in this group, characterized by a tendency towards medial displacement of the distal fragments, two involved the entire tibial epiphysis as a unit (third degree according to Ashhurst and Bromer[2]), four involved fracture through the tibial epiphysis (second degree) and eight involved merely a minimal medial displacement of the fibular epiphysis (first degree). (Fig. 3.)

The third degree injuries were sustained at three and a half and fourteen and a half years; one was a fall from a second story window, the other a football injury. In the case of the young child there was a 20 per cent slip of the tibial epiphysis but the medial aspect of the tibial metaphysis had been driven through the epiphyseal disc after this displacement. In the other case there was a 25 per cent medial slip with a large medial metaphyseal fragment representing 20 per cent of the width of the metaphysis. This second case was treated by closed reduction the same day of injury. However, the younger child had an open reduction with three Kirschner wires transfixing the replaced epiphysis. In spite of an excellent reduction, a progressive varus tilt of the tibial epiphysis developed. By the age of six years she had a 20 degree varus deformity of the ankle, and open wedge osteotomy was performed without lateral epiphyseal arrest. Three years following this, at the present time, she is ready for repeat osteotomy for correction of varus recurring with further growth. (Fig. 4.)

The second degree adduction fractures showed cracking off of the internal malleolus due to fractures through the tibial epiphysis. The ages were seven, eight, ten and fifteen years with three males and one female. The mechanisms of these injuries included being hit by an automobile, a crush due to direct



3A 3B

FIG. 3. Adduction fracture separations of the distal tibial epiphysis. A, third degree type showing the entire tibial epiphysis displaced but with medial metaphysis driving through the epiphysis like an ax. B, second degree type showing medial malleolus separated by a fracture through the epiphysis itself.

violence, a jump from a fence and a slide to second base. Two of these four patients required open wedge osteotomies for the correction of varus tilt of the ankle mortise, and two cases were followed up far past maturity, neither of them having developed a varus tilt.

TABLE VIII

DEFORMITIES DUE TO SECOND AND THIRD DEGREE ADDUCTION INJURIES

Three of 6 cases (3 of 4 under 12 yr.)	50%
Average age at time of injury (yr):	
Developing deformity*	7.16
Not developing deformity	12.16

* Deformity in all cases due to medial closure with varus tilt ankle and shortening. Those not developing deformity were followed up to ages nineteen, thirty-three and thirty-four years.

Table VIII summarizes the results in the second and third degree adduction fractures and includes, we believe, all of the clinically significant deformities resulting from injuries to the ankle epiphyses in our series. The grave prognosis accompanying second and third degree adduction injuries is quite obvious.

In the first degree adduction injuries with separation of the fibular epiphysis only the ages ranged from seven to fourteen years with six boys and two girls; the injury was usually sustained by an inversion type of twist of the ankle and displacement of the fibula was usually minimal, being less than 10 per cent of the width of the metaphysis in all cases. The indirect trauma required to produce this injury was minimal; even a twist of the ankle while walking on uneven ground at times accounted for the injury. Treatment was at all times conservative and non-weight-bearing lasted only for a few days. No difficulties were noted on the follow-up examination of four cases.

COMMENTS

Review of the literature at this time reveals more clearly than had been suspected in the past the unique role which second and third

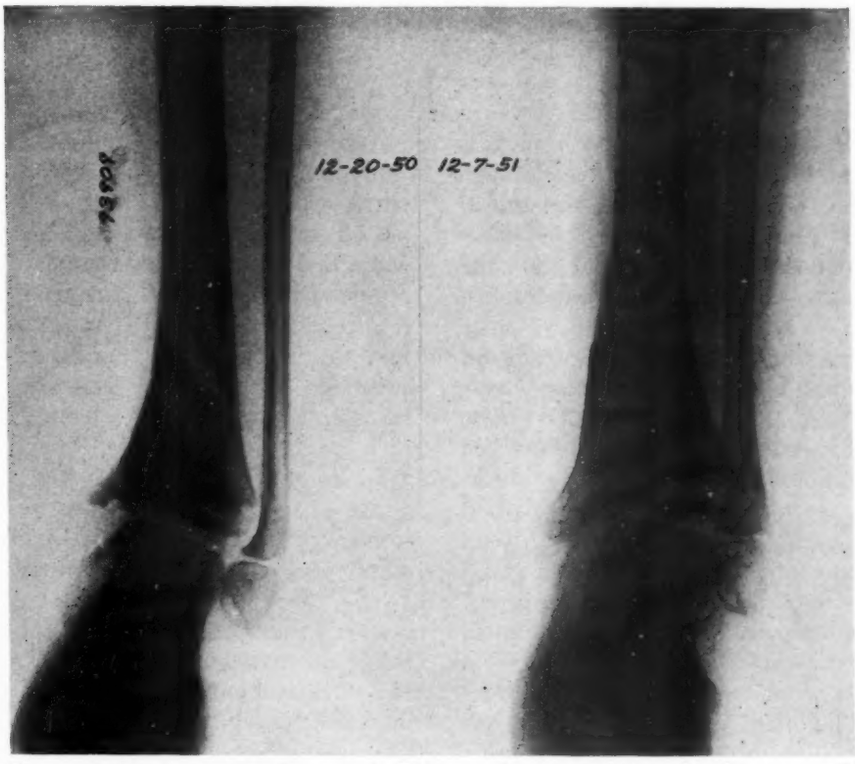


FIG. 4. A, fracture separation seen in Figure 3 three years later, showing varus tilt of the ankle mortise due to premature closure of the tibial epiphysis medially. B, same after open wedge osteotomy without lateral epiphysiodesis.

degree adduction type epiphyseal fracture separations play in significant deformities about the ankle.[1,6,10,12,17,18,21,22] It is this group of injuries which is characterized by a fracture through the epiphysis itself, and this disruption of the continuity of the epiphysis accounts for the subsequent deforming growth.

In 1863 Foucher[4] pointed out that the weak link in the epiphyseal-metaphyseal junction was just beyond the zone of provisional calcification through the developing trabeculae of the metaphysis. Poland,[21] most notably, elaborated upon this theory, and the roentgenologic appearance of the thin lamellar disc of metaphyseal bone which is sheared off at the time of injury was even utilized by Werenskiold[23] in the diagnosis of minimal slipping. In external rotation or abduction injuries at the ankle the large element of shear in the force involved effects a transverse fracture through this weak point carrying the intact epiphysis past the vertical lateral border of the tibial metaphysis. In adduction injuries, however, the medial border of the talus, after epiphyseal separation or fracture of the fibula, exerts a compressive force through the tibial epiphysis as its medial migration is blocked by the medial malleolus.

One of us[7] has experimentally reaffirmed the fact that the force which can be exerted through bone in compression is many times greater and probably more destructive than that which can be exerted through shear. Thus the epiphyseal disruption occurring in the adduction injuries is explained by the significantly greater forces which are transmitted to the epiphysis in this group of cases, and clinically most cases of growth deformity are seen following adduction epiphyseal injuries.

It is the repair process following this disruption which probably blocks the epiphysis medially, for a reparative ossification of this defect would accomplish the same result as operative epiphysiodesis according to the method of Phemister.[20] Bishop[4] and Gill[12] have both argued that even adduction forces will produce shear and that epiphyseal fracture and deformity will not result in cases under the age of nine when the zone of preliminary ossification is especially weak. Followed cases in this and other series stand in direct opposi-

tion to this belief. Our case of second degree epiphyseal fracture due to axial compression is but another example of the role which a large element of compressive force plays in the disruption of an epiphysis. Both in this case and in the adduction injuries the damage to the epiphysis was apparent in the initial x-rays taken at the time of injury and thus growth deformity can be predicted at the time of injury in spite of previous statements to the contrary.[10]

In connection with the influence of age on epiphyseal slipping and fracture, Bishop[4] drew upon the observations of Poland[21] and Werenskiold[23] and suggested that the tough bond between the epiphyseal disc and the metaphysis in the case of older children explained the fact that he had only four cases fifteen and sixteen years of age. However, we found twelve fracture separations in this age group and as one might expect, all of these were in males.

Experimental work in the past by Haas,[13] Gatewood and Mullen,[11] and Phemister[20] has suggested that cessation of epiphyseal growth could result sometimes after the periosteal stripping accompanying an epiphyseal displacement. It is interesting to note in this connection that of fourteen epiphyseal fracture separations under the age of fourteen years with significant displacement, clinical shortening, due possibly to the injury under investigation, occurred in only one case and in this instance it was only one-quarter of an inch. The remaining cases included five in which incomplete reduction of the epiphyseal separation was spontaneously corrected through subsequent growth.

The mechanism for this spontaneous correction of tilt at the ankle mortise was indirectly suggested as early as 1863 by Heuter and was elaborated by Volkmann in 1869.[5] He pointed out that abnormal differences in compression caused unequal and asymmetric growth of a joint. Experimentally Murray[19] and others have shown that pressure modifies to some extent the form of a growing joint in spite of its inherent genetic tendencies. Thus the advice of Bisgard[3] and Eliason and Ferguson[10] cannot be too strongly stressed in dealing with epiphyseal fracture separations at the ankle; namely, that it is far better to accept an imperfect reduction than to risk epiphyseal damage by remanipulation or operative intervention. The amount of correction which is possible spontaneously late in the growing period is demonstrated in several of our cases.

Why Bishop[4] had a preponderance of adduction type fractures (interestingly enough all without observed deformity, although he made no effort to follow-up his cases) cannot be explained. This is in contrast to the other reported series and to this study. However, it is interesting to note that we observed eight first degree adduction epiphyseal separations, a benign injury which had been thought by Eliason,[10] Kaplan[15] and Lewin[16] to be a rather rare type.

In 1945 Hatcher[14] suggested that the incidence of metaphyseal fibrous defects might in some way be correlated with the incidence of epiphyseal growth disturbances. Cottier,[9] in 1952, questioned an etiologic relationship between the posttraumatic metaphyseal hemorrhage occurring after a slipped epiphysis and the development of fibrous and cystic lesions in this area. None of our cases showed any such metaphyseal defect either at the time of injury or on follow-up examination.

SUMMARY AND CONCLUSIONS

1. These conclusions are based upon fifty-four cases of epiphyseal injuries at the ankle, thirty-three of which were followed up and upon those cases in the literature in which sufficient information for study has been obtainable.

2. Accurate reposition of the displaced epiphyses at the expense of forced or repeated manipulation or operative intervention is not indicated since spontaneous realignment of the ankle occurs even late in the growing period.

3. Growth deformity at the ankle can be predicted at the time of injury because it usually occurs in the adduction group and is accompanied by x-rays demonstrating a disruption of the epiphysis itself.

4. The factors responsible for the high incidence of permanent damage to the epiphyses in adduction injuries are discussed.

5. There is no evidence that massive displacement of the epiphyses results in clinically discernible disturbance of growth or in subsequent defects in ossification of the adjacent metaphysis.

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DISCUSSION OF PAPERS BY DRS. KAPLAN AND CRAIGHEAD, MACLAUGHLIN AND GARCIA, SPEED AND BRACKIN, COUGHLIN, AND CAROTHERS AND CRENSHAW

Kellogg Speed (closing): I wish to mention one patient of mine (Case 21) in corroboration of the value of the tomogram in fusion of the hip. This woman had a prolonged painful morbus coxae senilis and was first seen in 1940, but was carried along for a while by other methods. Finally the hip was fused in 1942, sometime before a film, was taken.

In 1943, a retake film was made. Fusion remained perfect. We were sure she had a fusion, and so we let her walk, bear full weight and do all her work.

In February, 1948, she had a fall and sustained an intertrochanteric fracture of this femur with separation, but the fusion was so firm, as confirmed by our tomogram, that it never was disturbed.

This was simply treated by abducting the leg and putting it in a plaster spica. In a few weeks she had another firm union with full walking power.

Ralph Carothers (Cincinnati, O.): I would like to pay my respects to the Parham band. It is a good piece of apparatus to use, and I think it has been damned unnecessarily. I have found it useful in spiral fractures of the femur in which an intramedullary nail was used.

With regard to epiphyseal injuries, I would like to recall a paper by Dr. Fraser Gurd entitled, "Twenty-five Ways to Get in Trouble with Fractures." In this article, he said in any epiphyseal injury, do not forget to tell the parents that the bone might grow crooked.

Campbell Gardner (Montreal, Canada): I would like to comment on a case involving the Parham bands. A twenty year old girl came to me after being treated in Austria for a simple fracture of the tibia and fibula. The Austrian surgeon explained to her that the quickest way to get these fractures healed properly was to have Parham bands put on. She agreed to this, and the bands were duly introduced. The surgeon told her that Parham bands should never be removed, that the plaster cast should be taken off in two months, and that she should be able to walk perfectly.

I did not know this surgeon. However, I did have the patient's x-rays and there was a most magnificent reduction of the lower end of the tibia. I decided to keep the fracture immobilized for four months and take the plaster off then.

At the end of four months she started to walk and everything was fine. At the end of five months she felt a click. Fluoroscopic examination revealed nothing definite. However, at the end of six months, her leg had swollen to twice its normal size and it was obvious something was going wrong. We put her leg back in plaster.

At the end of seven months we still were not able to demonstrate any change in the fracture. As far as the radiologists could see, it was so obscured by the Parham bands that no one could tell whether it was united or not.

At the end of eight months it was perfectly obvious we had to do something.

I telephoned the Austrian surgeon who said he had treated many fractures like this one and they were all perfect. I discovered afterward that he had done twelve, and all of them within the year.

However, at the end of twelve months we got the Parham bands off, still not knowing whether the bone was united or not. It was not united at all; in fact, there was a large amount of soft, mushy material in between the two ends. Once we took the bands off, fortunately, the patient healed perfectly.

I believe all of you men are going to be faced in the near future with the idea of patients going to Europe to ski in the winter. It is becoming a more and more prevalent idea. I would suggest you tell these patients that if they should fracture a leg in Europe it is simple to have a plaster applied temporarily, be flown back to the United States and be treated by their physician as he desires.

As Dr. Coughlin suggests, if the Parham bands are put on just the right way they work out beautifully. I discovered from the Austrian surgeon that he had a special instrument made to draw the Parham bands tight. This instrument resembles, I have discovered since, the same sort of thing used on bales. The Austrian surgeon drew these Parham bands sufficiently tight so that there was obviously no circulation in this bone.

I cite this case not with the idea of criticizing Dr. Coughlin's paper but because I think Parham bands should be put on by the man who is subsequently going to handle the fracture. Otherwise, I think he had better not handle it.

Isidore Cohn (New Orleans, La.): I would like to compliment Dr. Kaplan on the clear, concise manner in which he presented principles, and also the results which he has obtained.

I was very happy to hear Dr. Coughlin speak of the Parham band, but I am sorry he failed to mention Dr. Martin. Dr. Martin many times said that Dr. Parham conceived the idea and he delivered the baby, having been an engineer before he became a doctor. He adapted the principle of the cotton bale band for his use in fractures.

For the benefit of the doctor who was criticizing the Parham band being used, I would say that neither Parham nor Martin ever intended it to be used on a triangular surface, but rather on a round surface.

I also was rather amazed to hear that the Parham bands do not become enclosed by callus. From my own personal experience many years ago I can testify that it required a good deal of chiseling in one or two cases to remove the band. I would also say that it was not necessary in the past to remove the bands when they were put on. It is important for those who intend to use them not to depend on these bands to maintain length. They only maintain apposition. Weight bearing favors one part of the bone to slide over the other.

In future presentations I hope Dr. Coughlin will mention Dr. Martin when referring to the band, because it is properly known as the Parham-Martin band.

Preston A. Wade (New York, N. Y.): I am very pleased to discuss Dr. Coughlin's fine paper in which he has presented two subjects, both of which are somewhat controversial and will undoubtedly cause considerable comment.

The use of fixation of the fibula in difficult fractures of the tibia is not new, perhaps, but it is forgotten by many of us and is a very useful procedure. Perhaps one reason why fixation of the fibula is not attempted more often is because of the fact that when the fibula heals promptly and the tibia is delayed, the fragments of the tibia may be kept apart by the solid fibula.

I have never used a plate on the shaft of the fibula, as Dr. Coughlin has shown in his cases, but I have used intramedullary rods. I think that the intramedullary rod, particularly near the ankle joint, is a very useful means of stabilizing difficult types of fractures.

I believe that in many cases an intramedullary rod is preferable to a plate. However, I cannot quarrel with the cases he has presented. They, I believe, have been very well done.

His second subject, which concerns the use of the Parham band, is also a controversial one. Many years ago the Parham band was used quite extensively. However, because they were made of a poor type of metal and were placed too tightly in certain fractures, the bands became unpopular, and in recent years any circumferential wiring or bands were thought to be a poor type of treatment. Certainly, if the bands are put on too tightly and if they are left on for a long period and are not removed, they may cause bone necrosis, interference with circulation and a fracture at the site of the metal.

In recent years I have had occasion to take care of several cases operated upon by Dr. Moritz at Sun Valley. In all of these Parham bands were used and in all the results were excellent. I re-

moved the Parham bands from these patients and found that they were never too tight and had never caused resorption of the bone beneath.

Therefore, I believe that there are indications for Parham bands in certain fresh fractures of the tibia as well as those in which one used intramedullary rods, for instance, in a femur where circumferential wiring or band is necessary to approximate fragmented parts of the bone.

I would like to say a word or two about the other papers, particularly the one by Dr. Kaplan on two-plane fixation of fractures of the femur. His paper was very well presented and the results are excellent. I believe that intramedullary rods, however, are preferable to other types of fixation for the femur. I cannot see that this method has any advantage over the intramedullary rod, and the intramedullary rod has one additional advantage to the six or seven he listed, and that is early weight-bearing. The intramedullary rod can be inserted, also, with much less trauma and with a much less extensive operation.

I. W. KAPLAN (closing): Two-plane fixation has a wide range of adaptability for most fractures of the shaft of the femur. In fact in some cases it may be the only method you can use, unless you wish to apply casts or treat them by traction. For example, in our series of eighty-one femoral shaft fractures there were two intertrochanteric and one femoral neck fracture complicated by shaft fractures. Two-plane fixation on the shaft fracture was an easy and effective means of fixing the fragments.

There are reported cases of pathologic and open fractures treated by intramedullary nailing. It is not surgically sound to me to drive a large nail through a malignant tumor mass or through a potentially infected area to a clean one. Two-plane fixation at least keeps the tumor or infection confined to one area.

The femur heals by endosteal and periosteal callus. In many cases the medullary canal might be completely obliterated. In second fractures, such as the patient who sustained a fracture of the upper third of the femur and seven years later a fracture of the lower third, it might be quite difficult or hazardous to drive a large nail upward or downward in the medullary canal as it might result in another fracture. Two-plane fixation in such cases is an easy way of handling them.

EDWARD J. COUGHLIN, JR. (closing): I hoped when I presented this paper that it would cause a little controversy, and I am glad to see that it has. I would like to thank all the discussers for their remarks. Dr. Carothers spoke about using a Parham band elsewhere. We have used it in the femur to augment intramedullary nailing and also in the humerus.

I think one tendency, though, in using the band in a bone which is rather deeply buried in a large muscle mass is that you are more and more prone to leave the band in because it means a more major operative procedure. I would like to repeat again and again that these bands must be removed. I do not think there is any question about it. I am sure that is the reason they went into disrepute before, and I am sure if we leave them in again now, regardless of the site, we are going to get into trouble once more.

Dr. Gardner spoke about the woman from Austria; I think he waited just about forty-four weeks too long before removing the band.

My apologies to Dr. Cohn. Originally I had it as the Parham-Martin band, but dropped it off because I wanted to save a few words.

The point that he made of the triangular surface, I think, again is very important. On one occasion we tried to put a band down too low on the flare of the tibia, and as was perfectly obvious, the band skidded up and we had to take it off.

He spoke about the band being covered by callus when he removed it. As yet I have not seen that and again I wonder whether the band was not left on too long, because at eight weeks it is not covered over by callus; there is just a small amount of fibrous tissue.

I want to stress again that these bands must be removed.

Posterior Dislocation of the Shoulder

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WHEN reviewing the literature on posterior dislocation of the shoulder, one cannot help but be impressed by the repetition of the words infrequent and frequent, as it is agreed that posterior dislocations of the shoulder are infrequently seen but frequently missed.

However, it may be that as we become more conscious of this lesion, the incidence will increase, as is typified by my own experience wherein eighteen months following the first case, ten additional cases were collected without too much difficulty. I also know of nine other cases which have not been published.

So, it would appear that while these lesions may not be frequent, they may not be as rare as previously thought.

At the Boston City Hospital in this eighteen-month period, there were 162 dislocations of the shoulder, seven of which were posterior, an incidence of 4.3 per cent. Of the eleven cases presented, two are bilateral, giving a total of thirteen posterior dislocations. Of these, eight were acute and five were chronic recurrent. Six were associated with fractures and four with defects of the anteromedial aspect of the head. Of the eight acute cases, five were not diagnosed on initial examination.

Because of a simple x-ray finding which has greatly facilitated the early diagnosis of this lesion, thus averting the poor results which sometimes occur when the lesion remains undiagnosed, and because of the ease with which eleven cases were collected in a relatively short period of eighteen months, I think that my experiences with posterior dislocation of the shoulder are worth mentioning.

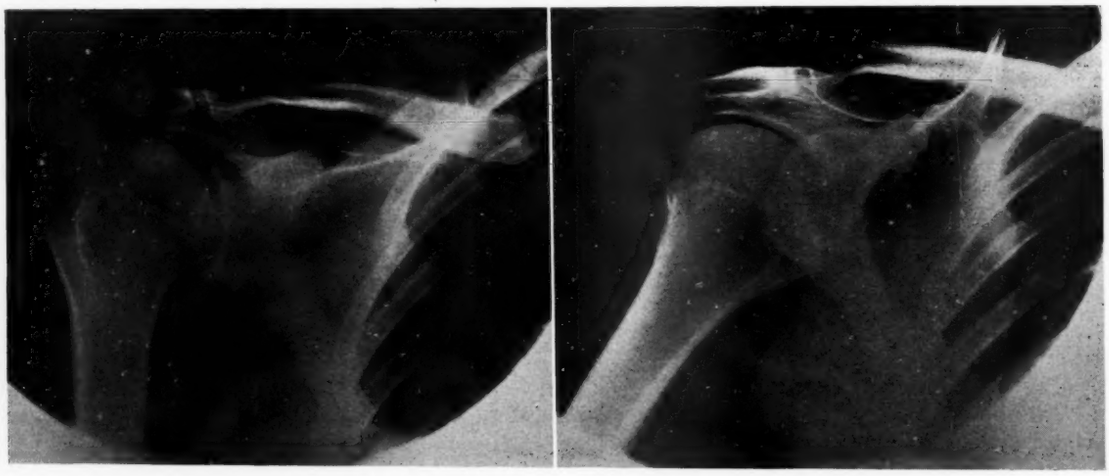

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FIG. 1. Anteroposterior view of the shoulder in external rotation with the inferior portion of the glenoid covered by the humeral head.

FIG. 2. Anteroposterior view of the shoulder in internal rotation showing the inferior portion of the glenoid covered by the humeral tuberosities.

Posterior dislocations of the shoulder may be classified under three types. First, that of rotational subluxation when the head of the humerus rests on the posterior portion of the glenoid rim, the head pointing posteriorly and the tuberosities anteriorly. This is the mildest but most insidious type. Second, the subacromial or retroglenoid type of dislocation which is of second degree intensity. Third, the subspinous type which is the complete posterior dislocation.

The most important single cause of posterior dislocation, of course, is trauma, usually direct on the flexed adducted and internally rotated

arm. It may also occur as a result of direct trauma to the anterior aspect of the shoulder or subsequent to epileptic seizures or shock therapy. In the chronic recurrent cases, mere dangling of the arm in flexion and adduction, such as in reaching over to pick up a piece of paper, may produce a dislocation. There may also be contributing congenital factors such as deformity of the glenoid due to increased concavity or decrease in the size or degree of normal obliquity. Relaxation of the capsule and retroversion of the humeral neck must also be considered.

With posterior dislocation of the shoulder, there is usually pain and disability with the arm held in adduction and internal rotation, although in the subspinous type, a degree of abduction may be present. There is flattening of the anterior aspect of the shoulder with prominence of the acromion and acromioclavicular joint and the coracoid process. External rotation is the most consistently lost function although, in the acute cases, all motions may be very limited and painful. There is prominence of the head posteriorly, especially in the subspinous type. This is not so prominent in the rotational subluxation or the subacromial types, especially if there is a large amount of hemarthrosis present. There are usually no associated neurologic or vascular changes, although in the subspinous type of dislocation, damage to the axillary nerve may be present.

One of the most interesting features of posterior dislocation of the shoulder is the x-ray findings.

It has been pointed out that in the anteroposterior view of the shoulder in external rotation, the inferior portion of the glenoid is covered by the humeral head, (Fig. 1), while in internal rotation, the glenoid is covered by the humeral tuberosities. (Fig. 2.) However, in posterior dislocations, the inferior portion of the glenoid is covered neither by the head of the humerus nor the tuberosities. While this is true in certain instances, it is not always so, especially in the humeral heads with a defect, or in the subspinous type of dislocation in which there may be overlapping of the inferior portion of the glenoid. The anteroposterior view then is not too reliable but, unfortunately, on the accident floor, too often the routine view of the shoulder is confined to an anteroposterior view and is a main reason why this type of dislocation is so readily missed.

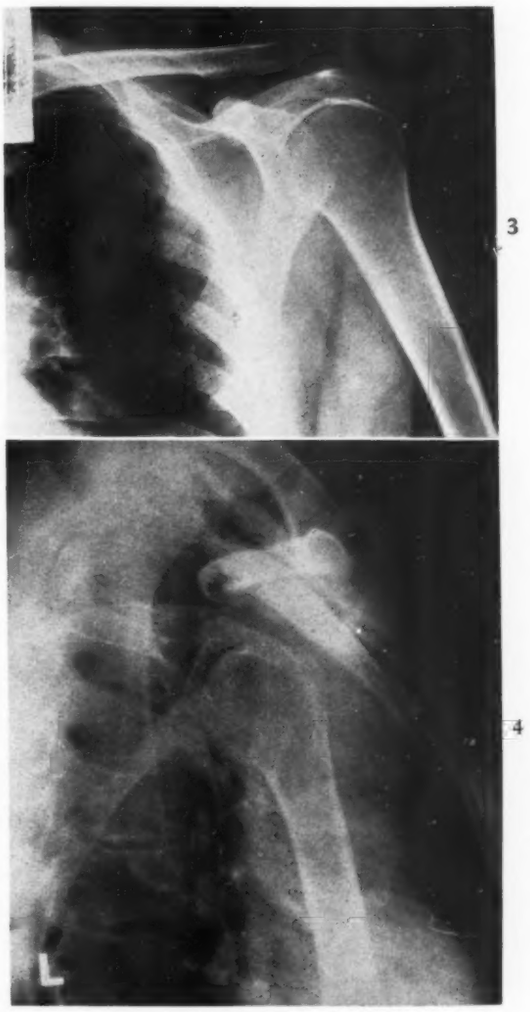

FIG. 3. Case 1. Anteroposterior view of the shoulder showing internal rotation.

FIG. 4. Same case. Lateral view revealing interruption of the normal scapulohumeral arch; type 1.

In order to facilitate the diagnosis, it has been suggested that an axillary or vertical view be obtained which reveals the lesion very well with the head dislocation away from the coracoid process. However, in the acute cases and especially in the rotation or subacromial types, abduction of the arm is usually not easily performed, if at all, and does not lend itself well to axillary views.

Stereoscopic views have also been advised, and, while these may be of value to a roentgenologist, they are not usually immediately available for interpretation on an accident floor.

The lateral transthoracic view reveals a humeral head to be postero-inferior to the

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FIG. 5. Case 11. Anteroposterior view revealing inferior portion of glenoid not covered by either humeral head or tuberosities.

FIG. 6. Same case. Lateral view reveals interruption of normal scapulohumeral arch.

FIG. 7. Same case. Lateral view postreduction revealing restoration of normal scapulohumeral arch.

glenoid. However, in certain instances, the glenohumeral joint may not be clearly visible because of the obesity of the patient or for other technical reasons, and it was in interpreting such a film with Dr. Albert Moloney, roentgenologist at the Shortell Unit of Boston City Hospital, that it was noted that there was an interruption in the normal scapulohumeral arch. This is a normal arch in the shoulder girdle formed by the axillary border of the scapula and the inferior portion of the neck and shaft of the humerus. It is comparable to the arch in the pelvic girdle formed by the upper aspect of the obturator foramen and the neck and shaft of the femur, known as Shenton's line. It was found that on all posterior dislocations

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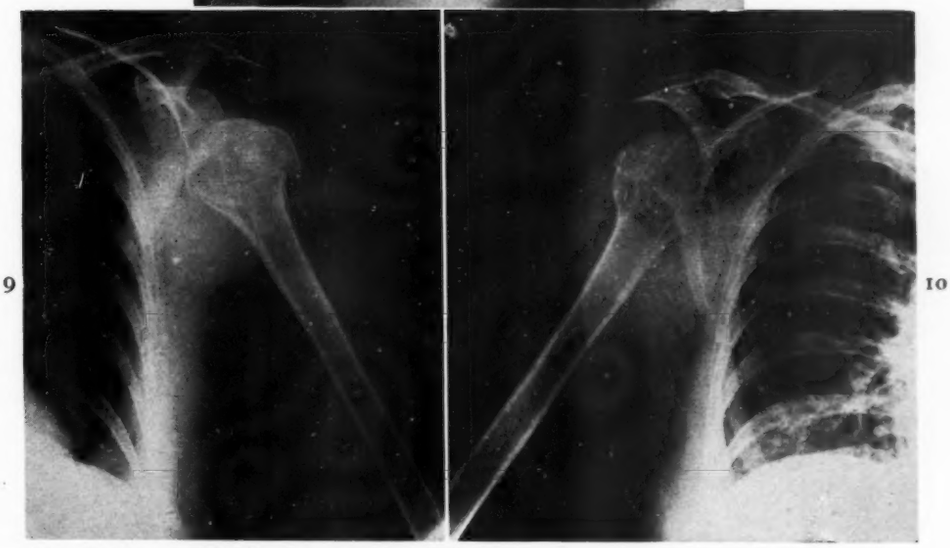

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FIG. 8. Case III. Single anteroposterior view.

FIG. 9. Case IV. Anteroposterior view of subspinous dislocation of left shoulder.

FIG. 10. Same case. Anteroposterior view of subspinous dislocation of right shoulder.

of the shoulder, there was an interruption of the normal scapulohumeral arch, which I have taken the liberty of calling Moloney's line.

Tangential or oblique views also reveal the posterior dislocation but, like the axillary view, are not taken routinely.

In chronic cases the diagnosis may sometimes be easily made by noting a defect on the anteromedial aspect of the humeral head.

The pathologic findings consist of the rotational, subacromial or subspinous position of the head with stretching of the capsule or stripping of it from the neck of the scapula. On rare occasions there may be tearing of the labrum or a rent in the capsule. In one of the patients upon whom we operated, the labrum and capsule were not torn. The capsule was redundant and there was also an absence of the long head of the biceps. There may be stretching of the rotator cuff posteriorly by the displaced head and anteriorly by traction over the glenoid. There may be an associated fracture of the head and neck. In chronic cases notching of the anteromedial aspect of the head and other associated degenerative changes may be present.

Treatment of the acute posterior dislocation consists of reduction under general anesthesia by traction and rotation, usually external, with direct forward pressure over the displaced head. In all cases in which closed reduction was attempted, it was easily accomplished. How-

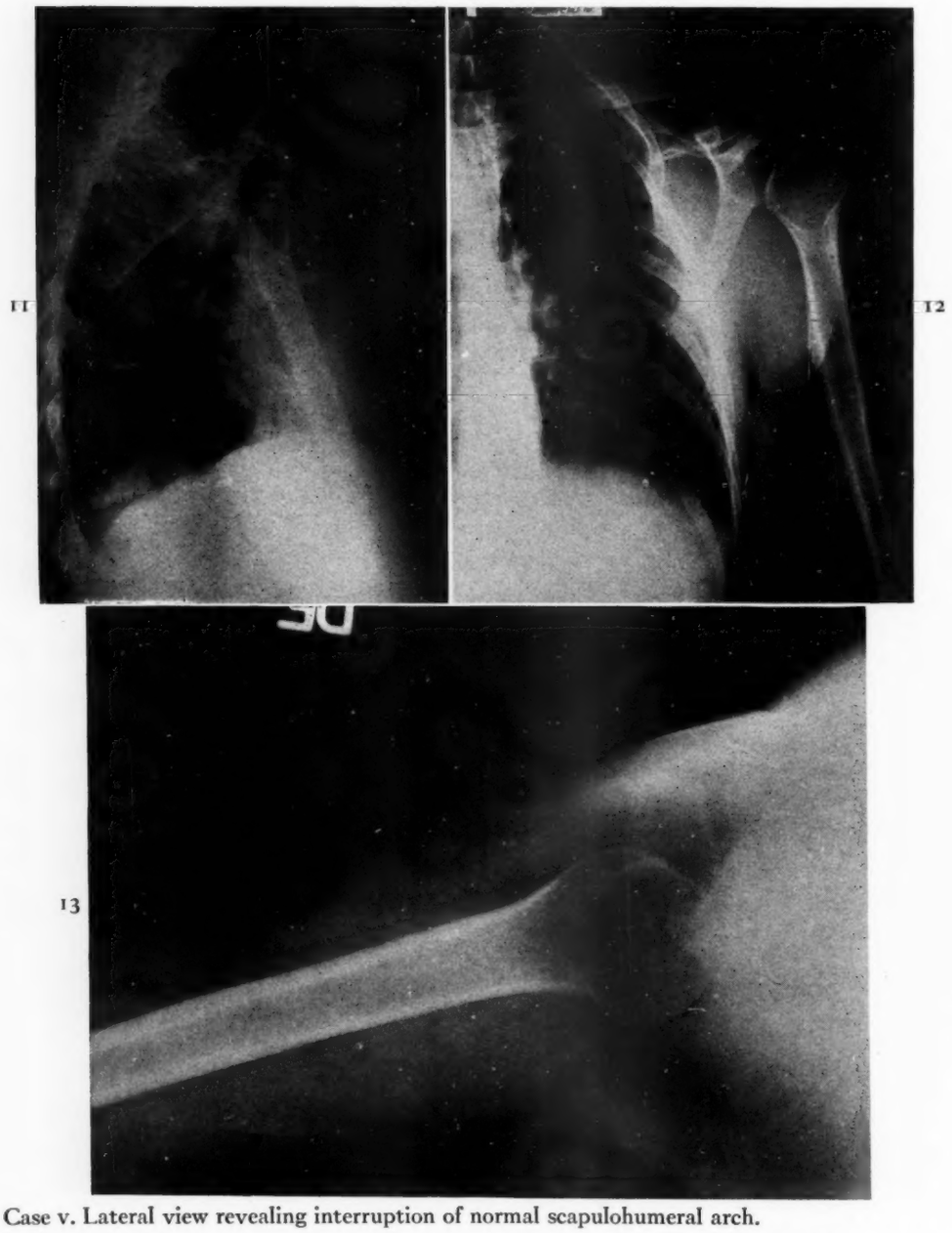

Fig. 11. Case v. Lateral view revealing interruption of normal scapulohumeral arch.

Fig. 12. Same case. Anteroposterior view revealing arm in internal rotation with only slight coverage of glenoid.

Fig. 13. Case vi. Axial view revealing posterior dislocation.

ever, in certain cases of acute posterior dislocation, as with anterior dislocation, it may be necessary to operate because of the interference of the long head of the biceps.

Immobilization is the same as for anterior dislocation, except that in certain instances, immobilization in external rotation may be necessary for stability. In the posterior recurrent dislocation, operation is the treatment of choice. It may consist of one or a combination of the following, such as transposition of the infraspinatus and teres minor tendons anteroinferiorly, reefing of the capsule, posterior bone block, especially if the defect in the head is present, Nichola operation, fascial and sling repairs or transposition of the subscapularis tendon to the defect in the humeral head. In any one of these, wire transfixion advocated by McKeever and Wilson may be employed. In this procedure, two wires criss-cross from

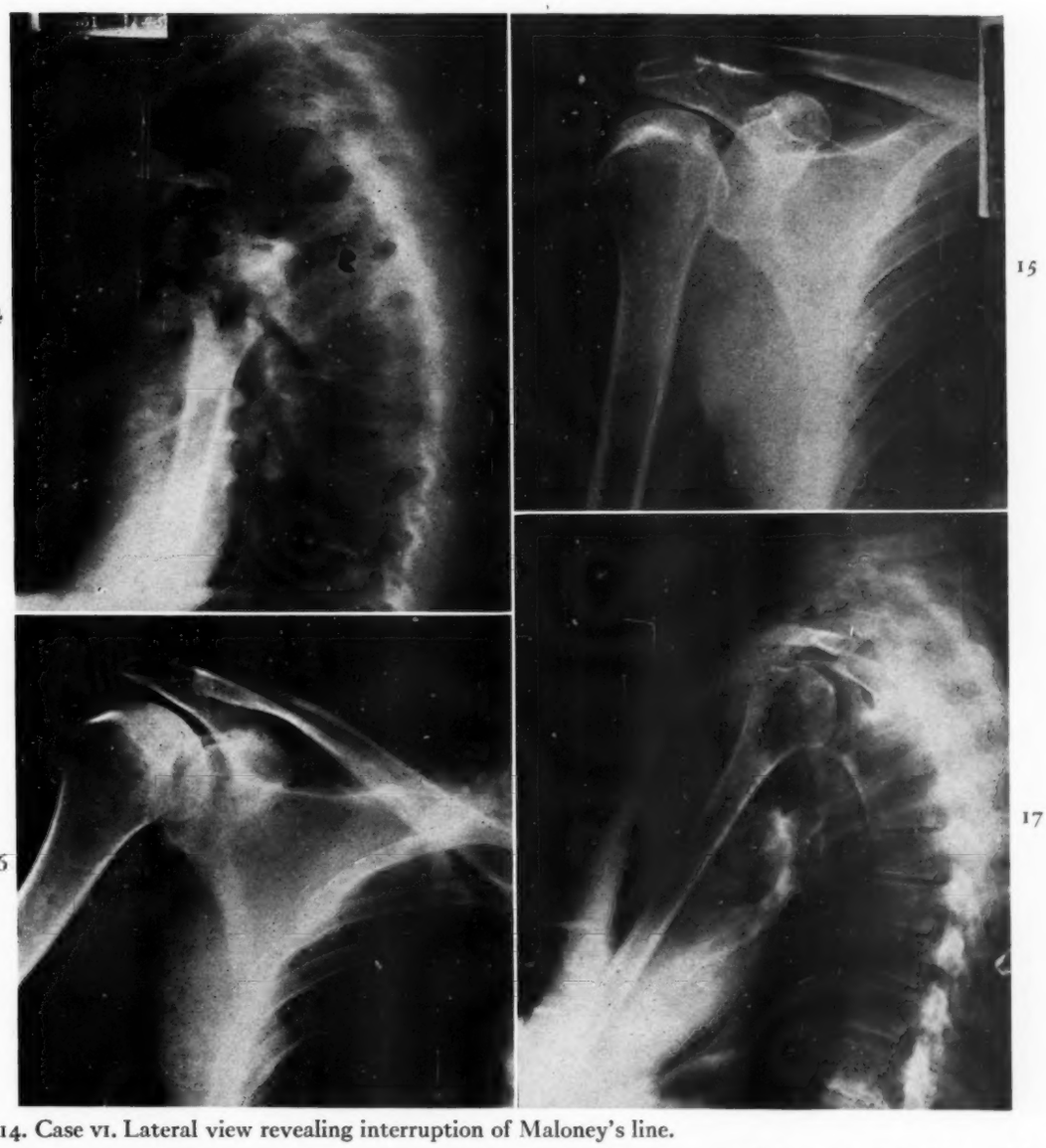

Fig. 14. Case VI. Lateral view revealing interruption of Maloney's line.

Fig. 15. Same case. Anteroposterior view showing the defect on the anteromedial aspect of the humeral head.

Fig. 16. Same case. Anteroposterior view postreduction.

Fig. 17. Same case. Lateral view postreduction.

the acromion into the humeral head and are allowed to remain for a period of a few weeks.

Of the foregoing operations, the transpositioning of the infraspinatus and teres minor tendons, plicating of the capsule, and the use of a posterior bone block if a defect in the humeral head is present have been our procedures of choice.

In the chronic permanently dislocated shoulder in which a false glenoid has formed, shoulder motions may be within normal limits with the exception of external rotation, which is markedly limited and may not even approach neutral. No treatment may be necessary. However, McKeever and Wilson believe that if this type of dislocation produces pain, fusion is the operation of choice. It may be that one of the simpler operations as mentioned should precede the more extensive fusion operation.

Case 1. J. H., a forty-five year old male, who stumbled on a curbing and fell, was aware of immediate pain and disability of his left shoulder. X-rays were taken which were reportedly negative. The patient was discharged with a diagnosis of

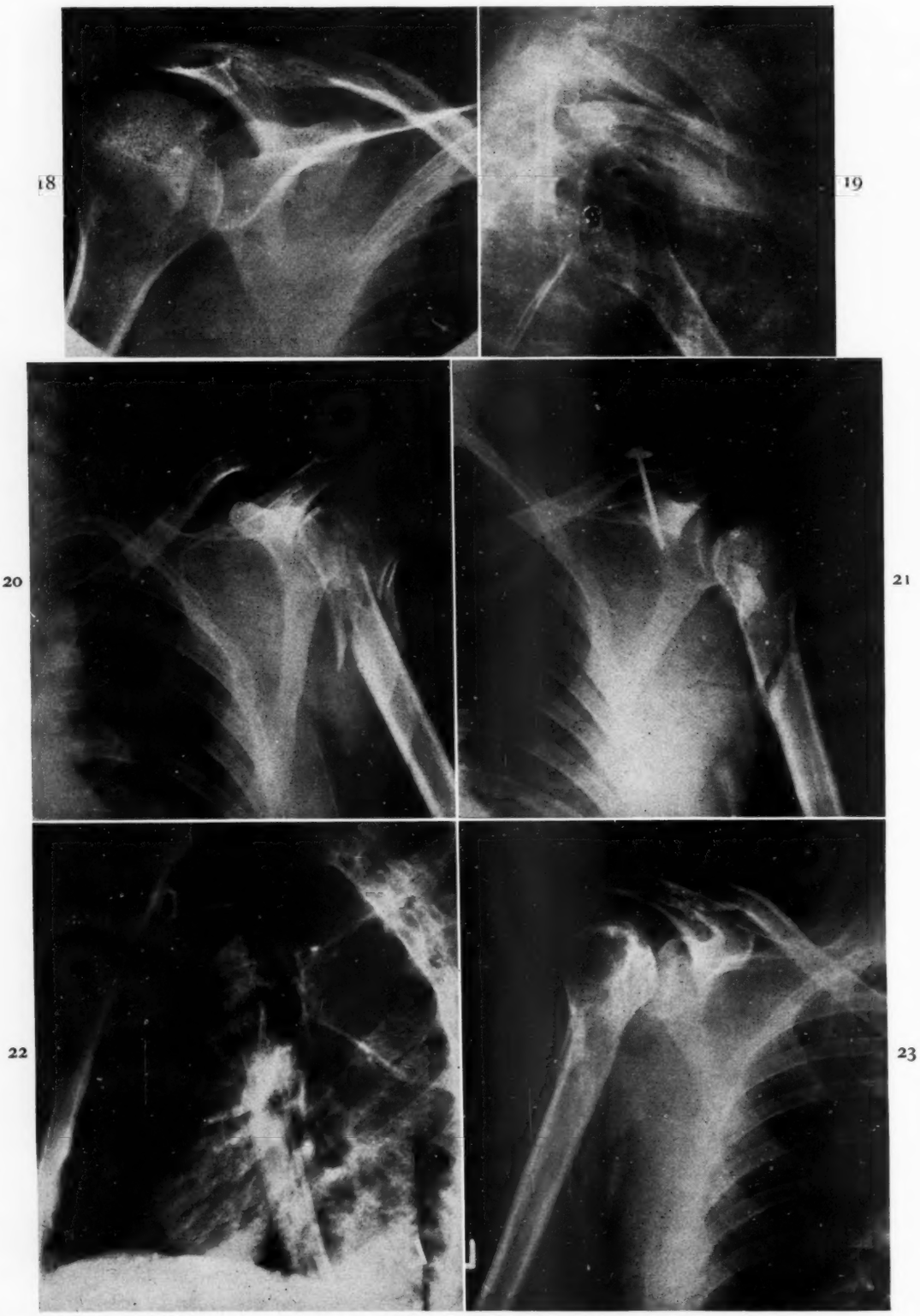

FIG. 18. Case VII. Anteroposterior view showing posterior dislocation with humeral defect.
FIG. 19. Same case. Lateral view revealing posterior dislocation with interruption of Maloney's line.
FIG. 20. Case VIII. Anteroposterior view revealing acromioclavicular dislocation and fracture of surgical neck.
FIGS. 21 to 23. Same case; see text.

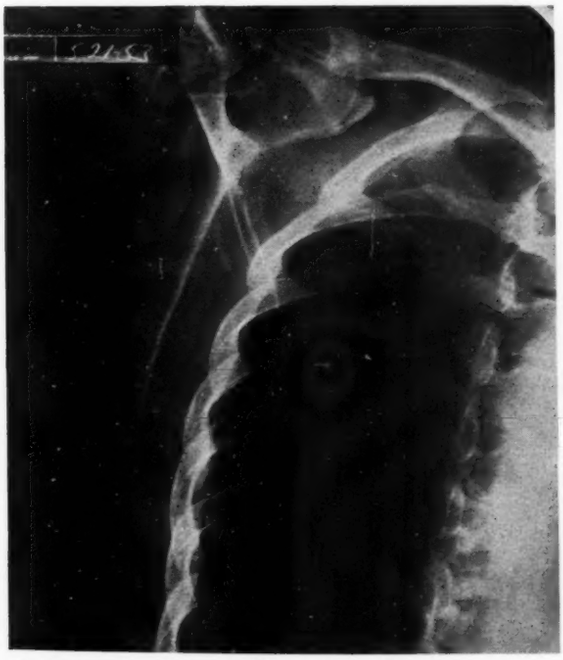

FIG. 24. Case VIII. Axillary view showing posterior dislocation of humeral head with proximal end of humeral shaft articulating with the glenoid.

FIG. 25. Case IX. Axillary view of posterior dislocation.

strain of the shoulder. Because of persistent pain and limitation of motion, he was seen by his family physician the following day who ordered x-rays of his shoulder which were again reported as negative. During this period of time, the patient had virtual absence of all motions of the shoulder. The following day, while washing dishes, he externally rotated his right shoulder suddenly and felt a "pop," subsequent to which his motions were within normal limits and the pain was gone. A review of the x-rays (Figs. 3 and 4) revealed the humerus in internal rotation with an interruption of the normal scapulohumeral arch, type 1.

CASE II. C. M., a forty year old male, was thrown forward with flexion, adduction and internal rotation of his right shoulder when the front wheels of his truck became caught in a rut. He was aware of immediate pain and disability of his right shoulder. He was taken to a hospital where a single anteroposterior film was read as negative and he was discharged as having strain of the right shoulder. The following day, he returned because of persistent pain and disability and, upon inspection, revealed a prominence of the acromioclavicular region and the coracoid, and a suggestion of a fullness of the shoulder joint posteriorly. There was little associated swelling. Repeat anteroposterior and lateral x-rays (Figs. 5 and 6) revealed the posterior dislocation and the interruption of the normal scapulohumeral arch. Under general anesthesia the dislocation was easily reduced with restoration of the normal scapulohumeral arch. (Fig. 7.) The shoulder was immobilized for three weeks.

CASE III. E. P., a sixty-five year old woman, fell on the outstretched hand with resultant pain and disability of her right shoulder. Clinically, there was a large amount of swelling of the joint but the head could be palpated posteriorly. A single anteroposterior film (Fig. 8) was taken and diagnosis of posterior dislocation of the shoulder with fracture was suggested on this single film in view of the lack of covering of the inferior portion of the glenoid by either the tuberosities or the humeral head. The dislocation was easily reduced under general anesthesia and immobilized for four weeks.

CASE IV. H. O., a young woman, was involved in an automobile accident while sitting in the front seat. She was thrown violently forward and, in an effort to protect herself, she placed her hands in front of her with the shoulders in adduction, flexion and internal rotation. She was aware of immediate pain and disability of both shoulders. Examination revealed a large amount of swelling of the joints. The heads were palpable posteriorly beneath the scapula spines. X-rays (Figs. 9 and 10) revealed bilateral subspinous dislocations with fractures. It could be seen from these views that this type of dislocation is not readily missed. Both shoulders are in internal rotation. Reduction was easily performed.

CASE V. P. G., a thirty-five year old male grocer, had been having difficulty with his right

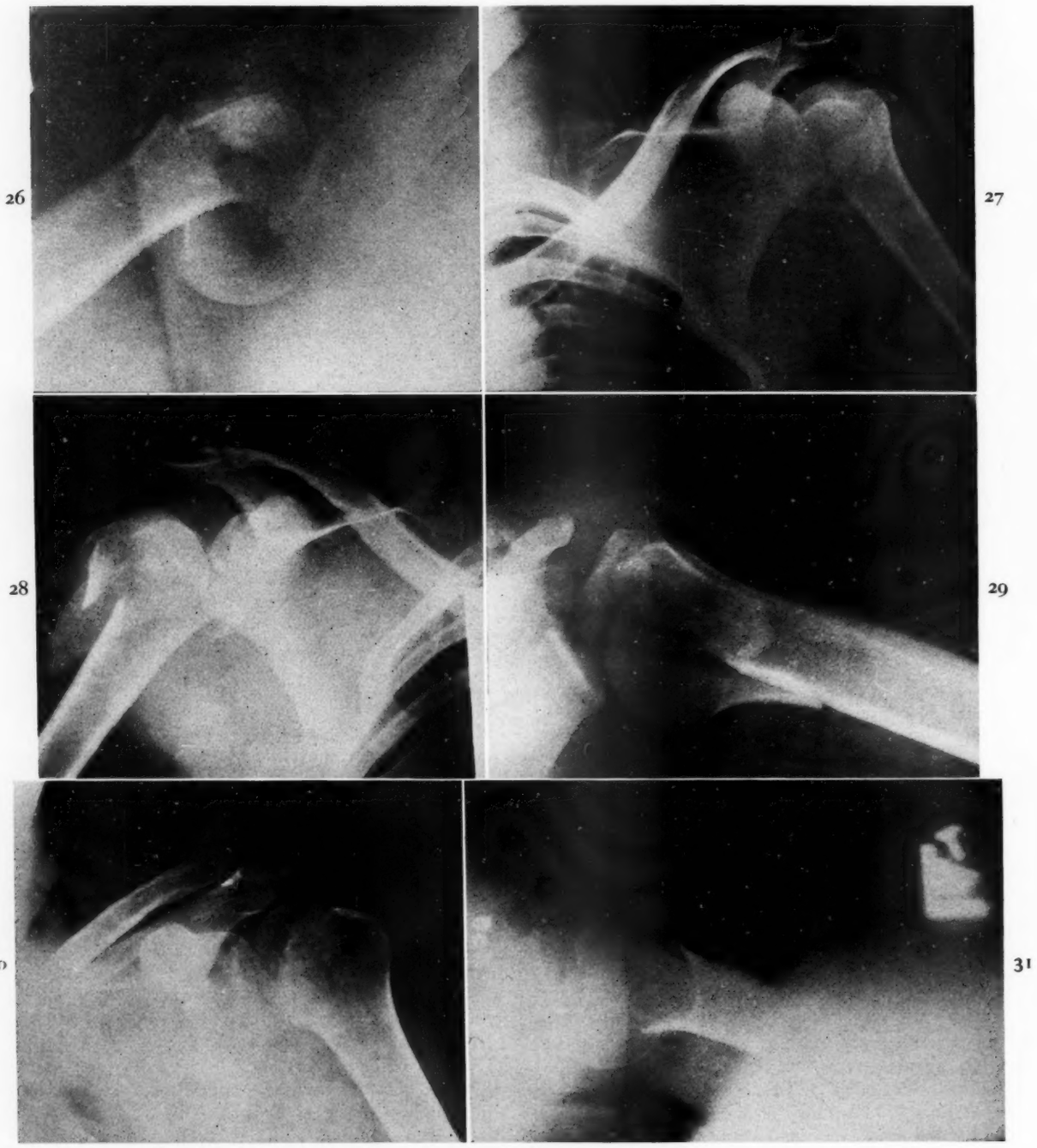

FIG. 26. Case x. Axillary view revealing fracture and posterior dislocation.

FIG. 27. Same case. Anteroposterior view revealing fracture; dislocation was not suspected.

FIG. 28. Same case. Anteroposterior view revealing fracture.

FIG. 29. Same case. Lateral view revealing posterior subluxation.

FIG. 30. Case xi. Anteroposterior view revealing posterior dislocation with defect on the anteromedial aspect of the humeral head.

FIG. 31. Same case. Axillary view confirming chronic posterior dislocation of the shoulder.

shoulder for several years, especially when he would reach to take something from a shelf. He would have pain and limitation of his shoulder which he sometimes could relieve by "juggling it." Because the incidence had been increasing, he sought treatment. X-rays (Figs. 11 and 12) revealed posterior dislocation. As can be seen, Moloney's line was of definite value in this case because the markings of the glenohumeral joint were not too clear. The patient could pop the shoulder in and out at will. Operation was performed through a modified Cubbin's incision. The capsule was found to be relaxed and partially stripped from the scapula. There was an absence of the long head of the biceps. The capsule was plicated and the infraspinatus and teres minor insertions were transposed antero-inferiorly. The arm was immobilized for three weeks and when followed up a year and a half later there had been no recurrence.

Case vi. D. McK., a forty-six year old man who had a history of chronic alcoholism, was admitted to the hospital two weeks subsequent to a fall because of a sloughing ulceration of the occipital region. He complained of some pain in his left shoulder with a normal range of motion except for the last 15 degrees of elevation and lack of external rotation. He stated that he had been having intermittent pain in the shoulder, but that it had not bothered him too much. X-rays (Figs. 13 to 15) revealed posterior dislocation of the shoulder. Figures 16 and 17 reveal postreduction views. Because of the personality involved, operation was not performed in this case.

Case vii. V. M., a forty year old man who had a history of chronic recurrent posterior dislocating shoulder, sustained a fall, with immediate pain and disability of the shoulder. X-rays revealed a posterior subacromial dislocation, with a defect on the anteromedial aspect of the humeral head. (Figs. 18 and 19.) The patient would allow no treatment for this condition and signed himself out of the hospital against advice.

Case viii. A. J., a young, man, was involved in an automobile accident, suffering an acromioclavicular dislocation with fracture of the surgical neck of the humerus. (Fig. 20.) After treatment, shoulder motions did not respond as expected. Subsequent films (Figs. 21 to 23) dealt only with the acromioclavicular dislocation and the fracture of the surgical neck until an axillary view was taken (Fig. 24) which revealed the posterior dislocation of the humeral head with the proximal end of the humeral shaft articulating with the glenoid. It can be seen, however, that in Figure 22, which was taken several months previously, there is poor visualization of the glenohumeral articulation in the lateral view; however, there is a definite interruption of the normal scapulohumeral line which, despite the fracture, should have made one suspicious of posterior dislocation. The patient's shoulder motions were seriously limited and the insertion of a prosthesis was finally resorted to.

Case ix. B. R., a forty-five year old woman, had suffered recurrent episodes of pain in her shoulder of many years' duration. She recalled that as a child she would have pain and disability of her right shoulder while bending over to start the motor of a washing machine. This could be relieved by manipulation. The patient had intermittent attacks whenever the arm was in flexion, abduction and internal rotation. Several months prior to being seen, she had leaned over to put on her shoes and became aware of immediate pain and disability of her right shoulder which was not relieved by the usual manipulation. She had been treated by her family doctor since that time for "bursitis." X-ray (Fig. 25) revealed the posterior dislocation of the head with the typical defect on the anteromedial aspect. Operation was advised which has not yet been performed.

Case x. R. T., a thirty-two year old Negro, was admitted to the hospital because of painful shoulders but was unable to give a clear history as to the etiology. Because of heat and swelling of his shoulder, he was admitted to the medical service with a diagnosis of rheumatoid arthritis. Subsequent films (Figs. 26 to 29) revealed bilateral posterior dislocations with fractures which required operative intervention. The patient is still under treatment.

Case xi. F. A., a sixty year old man, was admitted to the hospital with multiple injuries. He also complained of pain in his shoulders. X-rays (Figs. 30 and 31) revealed chronic posterior dislocation of the shoulder with notching of the humeral head. The patient had an adequate range of motion which he stated was not too bothersome and surgery was not advised.

SUMMARY

Thirteen posterior dislocations in eleven patients are presented with a discussion of the findings and treatment.

In disabilities about the shoulder joint the possibility of posterior dislocation should be kept in mind constantly because the lesion may be present more frequently than realized.

Because routine x-rays of the shoulder are most frequently confined to anteroposterior and lateral views, the value of interruption of the normal scapulohumeral arch (Moloney's line) as a diagnostic aid should be realized.

Acknowledgment: I wish to thank Dr. Robert Hartson and Dr. Howard Crawford for allowing me to use Cases No. iv and ix, respectively.

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Indications for Replacement of the Proximal Humeral Articulation

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THREE years ago a vitallium® replacement for the proximal humeral articulation was designed at the New York Orthopaedic Hospital, Columbia-Presbyterian Medical Center because the classic treatment for fracture-dislocations of the shoulder was found to be inadequate.[1] It was hoped that the results of resection of the head could be improved by the addition of a metal articular dome. This appliance has since been used in thirteen patients in our clinic. A description of the surgical technic and detailed case reports of twelve of these patients has been submitted for publication. Insufficient time has elapsed for a knowledge of late results; however, the information concerning the first two years indicates that replacement offers many advantages over resection. (Table I.)

Recent literature shows that Richard and Judet[2] in France have developed an acrylic shoulder prosthesis. This is being used by them and other surgeons on the continent.[3,4] In addition Anquin[5] in Argentina has independently devised another method of replacement and reports its use in four patients. Within the past two years a number of isolated case reports[6–10] have depicted the use of femoral prostheses in the shoulder, and Krueger[11] has reported favorably upon the use of a vitallium replica prosthesis in one patient. The rising interest in humeral replacement makes a discussion of indications and limitations seem pertinent at this time.

METHODS OF REPLACEMENTS

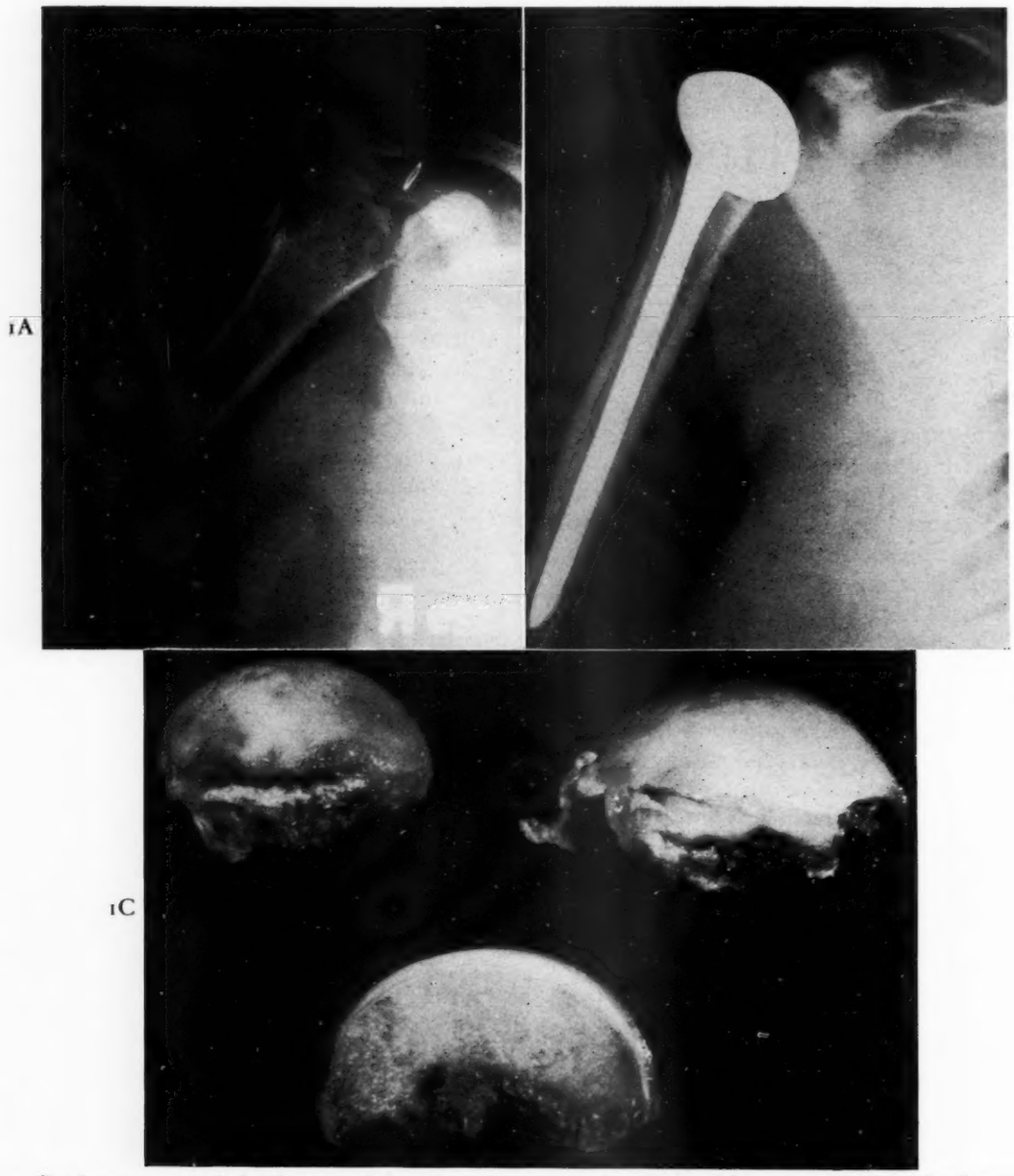
Richard and Judet[2] believe that unless the tuberosities are meticulously resected the remaining fragments of bone will give rise to an excessive type of bone regeneration and cause subacromial impingement. After removal of the head the tuberosities are excised by sharp dissection. The detached supraspinatus and infraspinatus tendons are sutured to a hole in the neck of the appliance. The body and stem of the prosthesis are detachable so that various stem sizes can be adapted.

TABLE I
SHOULDER REPLACEMENT—ADVANTAGES

Procedure	Pain	Strength	Range Motion	Return to Work (mo.)
Head excision[16]	Marked (until ankylosed)	Poor (until ankylosed)	Poor	5
Replacement[13]	Nil	Good (after 3 mo.)	Variable (improved)	2

Anquin has designed two acrylic appliances. Type I replaces the articular surface only. This is used if the tuberosities are neither displaced nor comminuted. If the tuberosities are retracted or fragmented, they are excised and the type II appliance used. The tendons are then attached to the humeral shaft as described by Jones.[12] The stems of these prostheses are of one diameter; and if they are found to be loose within, the humeri are transfixed with a screw. Anquin has found that the functional result following type I replacement is superior to that of type II.

The method we have employed differs pointedly from that of Richard and Judet and the Anquin type II operations in that the bony attachments of the rotator-cuff tendons are preserved. In comminuted fracture-dislocations the lesser tuberosity is displaced medially by the subscapularis and the fragments of the greater tuberosity are retracted posteriorly by the external rotators. The biceps tendon acts as a clear dividing line between the two zones. In this situation, following insertion of



1A 1B 1C

FIG. 1. Replacement repair for fracture dislocation. A, preoperative; B, head fragment was free of soft part attachments; C, wire loop fixation of the tuberosities after prosthesis insertion. Anatomical attachments of the rotator tendons are preserved.

the prosthesis, a fine wire is passed behind the greater tuberosity and in front of the lesser tuberosity and the fragments are pulled together. (Fig. 1.) A hole is provided in the neck of the prosthesis for anchoring these fragments in proper anatomic position. Longitudinal tendon defects are then repaired. The fragments subsequently unite to the shaft. Thus the rotator-cuff muscles retain their normal anatomic attachments. Five patients so treated have not regenerated bone as feared by the continental surgeons. Of course when the tuberosities are intact, they need not be disturbed. The appliance merely replaces the articulating dome. The prosthesis is constructed of vitallium with three stem sizes.

It is believed that the preservation of the bony attachments of these tendons is necessary for satisfactory function. It seems unreasonable to expect the rotator-cuff to attach to a prosthesis. Experience with the third method serves as the basis for the discussion to follow.

INDICATIONS

Approximately 314 fresh humeral neck fractures or shoulder dislocations have been treated by our fracture service during the past three years. From this number, head removal was indicated in only nine instances. The vast majority of humeral neck fractures can be treated by simple non-operative means. Occasionally an open reduction is necessary. Upon exploring the shoulder if it is seen that a reasonable amount of the articular surface is intact and retains soft tissue attachments, reduction of the fracture and preservation of the head is the procedure of choice. Rarely, the anatomic head is dislocated and deprived of soft tissue attachments (Fig. 1), or is fragmented. In this instance reduction is followed by avascular necrosis and traumatic arthritis. Resection is indicated. There is nothing new about this concept. Replacement prosthesis is indicated in only that small group of fractures in which the need for head resection has been clearly demonstrated by operative exploration. *Immediate replacement* should be considered in only three situations: fracture dislocation with extrusion of the anatomic head; "impression" fracture involving more than 50 per cent of the articular surface;[13] and "head-splitting" fracture.[14]

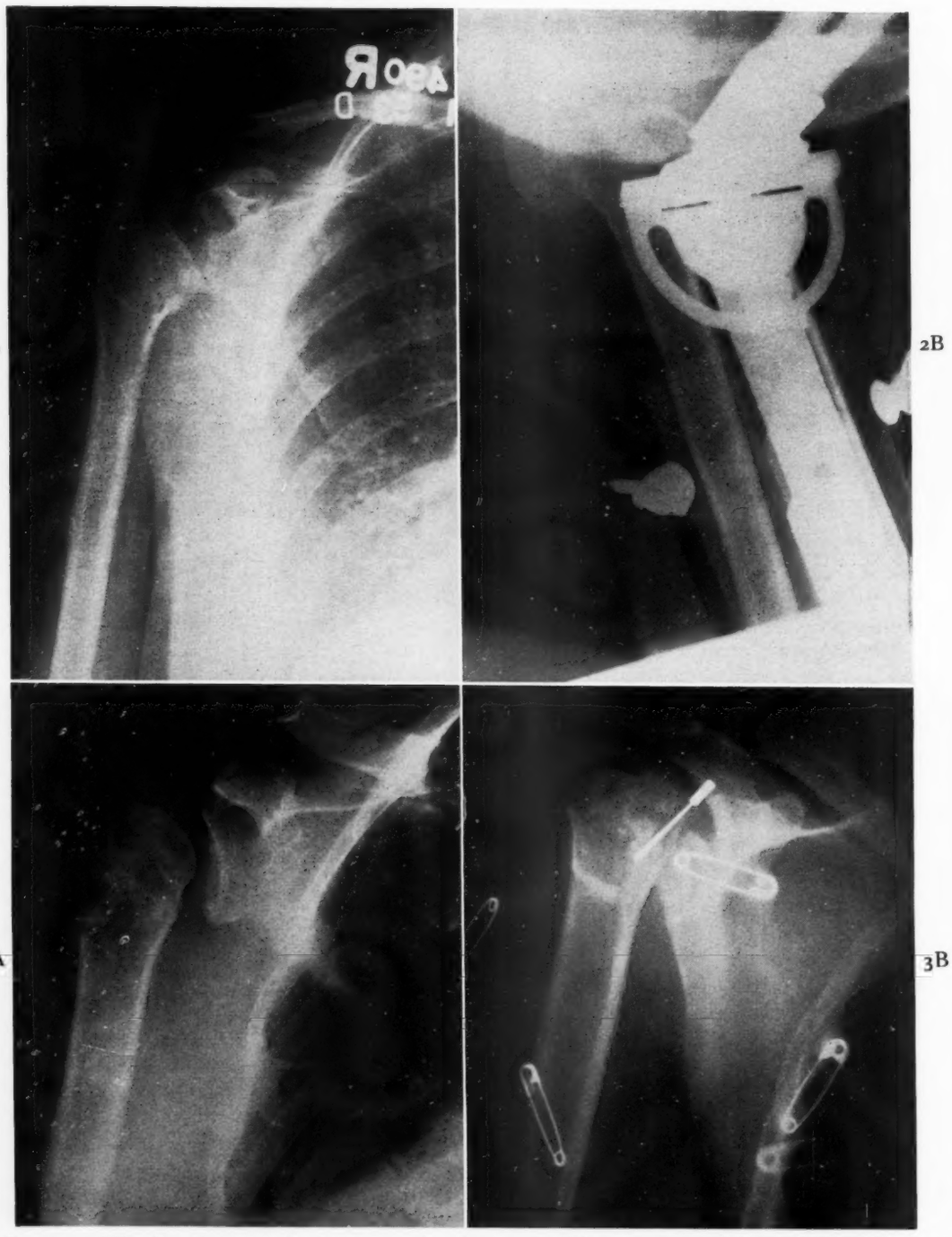
Fracture with Dislocation of the Head Fragment. This has been described in detail elsewhere.[1] Very occasionally there is a large head fragment retaining soft part attachments and blood supply. In this instance gentle open reduction is indicated. But usually the anatomic head is severed from all connections. (Fig. 1.) Resection has been followed by replacement and repair of the tuberosities in four such lesions. The results have been notably better in those instances in which operation had been performed within forty-eight hours. Old extracapsular lesions are accompanied by much soft tissue repair and pericapsular ossification and fibrosis has comprised the results in one such patient operated upon four months after injury. Fresh lesions have not resulted in this complication.

"Impression" Fracture. Sylwan[13] described posterior luxation of the humeral head due to the muscle spasm accompanying electroshock therapy and insulin shock. The anterior portion of the head is stove in as it strikes the posterior rim of the glenoid. (Fig. 2B.) When the indentation involves more than 50 per cent of the articular surface, the head luxates posteriorly as the arm is internally rotated. Such defects are too large to be filled by transposition of the subscapularis tendon.[15] In two such instances the defective head has been replaced. The prosthesis filled the joint cavity so that posterior luxation was eliminated. Several severe cases have also been observed in which the head, in addition to being collapsed anteriorly, was sheared off at the anatomic neck remaining posterior. Resection was obviously indicated and replacement was performed in two of these. Four months had elapsed between injury (electroshock) and surgery in one posterior fracture-dislocation and capsular ossification developed as was described in the neglected anterior displacement. This again suggests the need for early surgical treatment of extracapsular lesions. The greater tuberosity is characteristically intact in impression lesions and the rotator-cuff tendons are not disturbed by the replacement. Functional recovery is more rapid than in those situations requiring tuberosity repair.

"Head-splitting" Fractures. Intra-articular displacements of the anatomic head rarely require surgical extirpation. (Fig. 3A.) Generally a trial of non-operative therapy or reduction is indicated. However when the articular dome is comminuted, the prognosis is less hopeful.[14] (Fig. 3B.) Replacement has been performed in one such case in which the articular surface was fragmented into several unattached pieces.

In addition to the acute problems, one occasionally sees a patient with persistent pain due to arthritis from incongruity or late avascular necrosis. Shoulder motion is restricted, glenohumeral crepitus is marked, and at times the discomfort is more than the patient can endure. The usual non-operative measures (physical therapy, directed exercises, salicylates, hydrocortone, etc.) should be given a thorough trial before considering surgery. Arthroplasty should not be contemplated unless these measures have failed to relieve pain. The prime mission of the replacement is to relieve pain. Operation upon a painless shoulder merely to improve range is not justified. The indication for *late replacement* is persistent pain stemming from incongruity of the humeral articulation.

Avascular Necrosis. Garden variety humeral neck fractures occasionally give rise to



2A 2B

3A 3B

FIG. 2. Fractures following electroshock. A, "impression fracture" with 60 per cent of the articular surface stove in anteriorly and the remaining head dislocated posteriorly. B, axillary view of a posterior dislocation and fracture of the anatomic neck with 90 degrees rotation of the head.

FIG. 3. Compare these roentgenograms. A, articular surface intact; B, "head-splitting fracture" with fragmentation of the head. Replacement is indicated in B.

segmental necrosis of the head. Pain persists in spite of months of directed exercises and physical therapy. Two such patients were seen a year and a half to two years after injury. Their pain was relieved by replacement arthroplasty. Severe head changes developed in a third patient two years following open reduction. The malunited tuberosities were not disturbed at operation in these patients and, subsequently, they all regained more than 80 per cent of their glenohumeral motion and good strength.

Degenerative Hypertrophic Osteoarthritis. This condition is rarely seen in the glenohumeral joint as compared to the weight-bearing joints. It may be a result of trauma, caisson disease, burned out rheumatoid arthritis and other conditions. One such patient (Fig. 4) underwent replacement and when last seen nine months ago remained symptom-free. This suggests the value of this procedure in carefully selected situations; however, one must exclude other causes of shoulder pain such as calcium deposits, tears of the musculotendinous cuff and acromioclavicular arthritis.

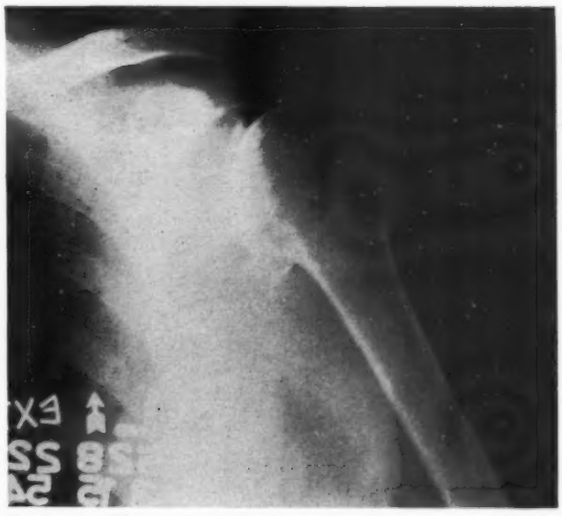


FIG. 4. Hypertrophic degenerative osteoarthritis following an injury three years previously. No fracture diagnosed. Pain was stopped by replacement after non-operative therapy failed.

LIMITATIONS

The success of any arthroplasty depends upon its having been done for the right thing and upon the right patient. Obvious general contraindications include osteomyelitis, tuberculosis and neuropathy. Three special contraindications should be considered: deficient musculature, massive loss of bone substance and periarticular disorder.

Muscles Inadequate. This may be the result of nerve injury, prolonged disuse or disruption of the rotator cuff. The patient depicted in Figure 5A was seen twenty years after an attempted arthrodesis and fifteen years after resection. Changes in the short rotator muscles had become irreversible.

Loss of Bony Substance. Tumors of the upper humerus may involve the tuberosities and the head. The result of a massive replacement and reattachment of the supraspinatus and infraspinatus tendons to the prosthesis in one such patient in our clinic did not invite repetition. (Fig. 5B.) It is believed that simple excision without replacement has given better symptomatic results; and although the arm is flail, function is as good as that of patients with large prostheses in whom the attachments of the rotator-cuff muscles are removed.[16]

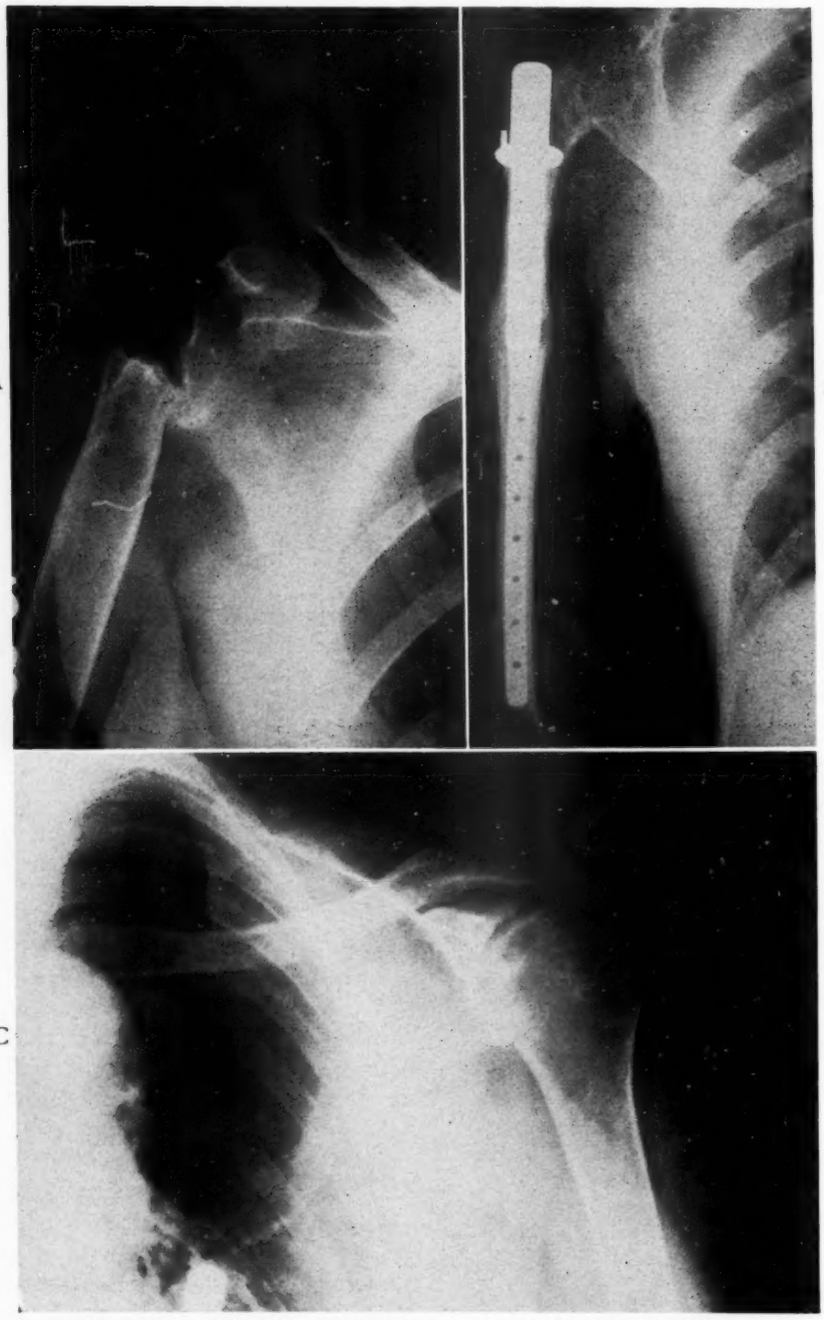
Periarticular Disorder. Rheumatoid arthritis often effects the glenohumeral joint. (Fig. 5C.) Surgical treatment should be reserved for the late residual stage when inflammatory disease has burned out and the problem has become that of secondary osteoarthritis. Active rheumatoid disease precludes mobilizing arthroplasty.

COMMENTS

Gurd[17] stated that "there has been a danger on the part of many of us to make the treatment of fractures appear to be so complicated that the men who actually must treat the fractures throughout the country have been at a very serious disadvantage." Recognizing this danger the purpose of this paper is to emphasize that sound principles of treatment for shoulder fractures have not changed. It is not possible to agree with those authors[4] who would treat a surgical neck fracture with a viable head by inserting a prosthesis. Replacement is justified only in those few situations in which there is no satisfactory alternative to removal of the head. It is merely a therapeutic adjunct to limited resection.

SUMMARY

The early symptomatic and functional results following removal of the humeral head have been improved by replacement of the



5A 5B 5C

FIG. 5. Limitations. A, fifteen years after resection of the head and tuberosities. Replacement is impossible on two accounts: (1) permanent change in the rotator muscles and (2) loss of bone. B, five years after massive replacement for chondrosarcoma involving the tuberosities and head. The rotator tendons were attached to the appliance but were ineffectual, rendering the arm flail and painful until fusion spontaneously occurred. Is replacement justified after tuberosity removal? C, this roentgenogram invites a prosthesis but active rheumatoid disease prohibits surgery now.

articular surface and preservation of the bony attachments of the rotator-cuff. The appliance should be used only in cases in which established surgical principles indicate the need for head excision. The literature is reviewed and limitations discussed.

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Repair of the Acromioclavicular Joint Using Nylon

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Many methods for the repair of acromioclavicular separation have been described. These may be divided into four main categories: (1) cast or bandage stabilization including pin fixation; (2) surgical repair of the dislocation; (3) fusion of the acromioclavicular joint; and (4) excision of the outer portion of the clavicle.[1,2]

Plaster cast fixation and Volpeau dressings with or without transfixion with a Steinmann pin or heavy Kirschner wire (Murray, 1940) can be used successfully in incomplete tears and sprains of the acromioclavicular ligaments, but in complete dislocations the percentage of failure is so great that it is not a procedure of choice. It has been estimated that at least 20 per cent fail.

Fusions of the acromioclavicular joint have been employed particularly in chronic dislocations of the acromioclavicular joint; and while they stop pain and stabilize the shoulder, they nevertheless cause limitation of shoulder function.

Excision of the outer portion of the clavicle, as advocated by Gurd,[1] is used by many surgeons for acromioclavicular separation but has as a disadvantage drooping of the affected shoulder and loss of muscle power.[3]

Surgical restoration of the acromioclavicular joint is a logical procedure and, in my opinion, is the treatment of choice. Many methods including the use of various types of material have been advocated with the use of wire, fascia lata (Bunnell, 1928), kangaroo tendon, silk sutures (Watkins[4]) including a lag screw (Bosworth[5]) from the clavicle to the coracoid process.

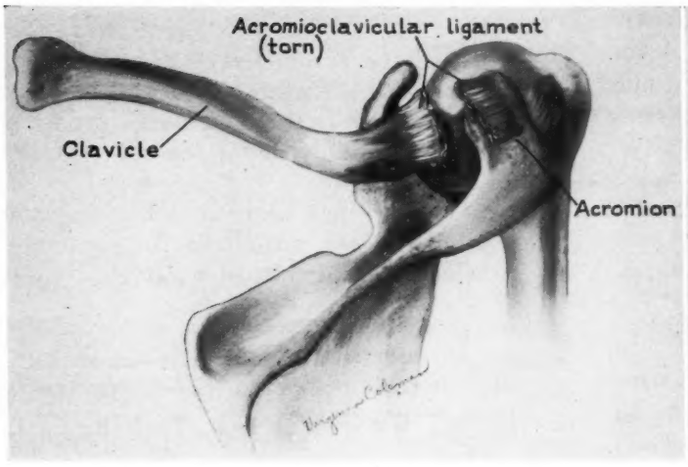
The excellent work by Inman and Saunders[6] has pointed out the necessity of maintaining the rotation of the clavicle to preserve full shoulder function. They have pointed out that any restriction of motion at either of the clavicular joints is promptly reflected in the total range of motion at the shoulder. They have concluded that rotation of the clavicle about its long axis and the action of its outer curve as a crankshaft is its most important function since this motion allows of one-half the total range of rotatory excursion of the scapula. The remaining half of scapular excursion is the outcome of the clavicular elevation at the sternoclavicular joint. Loss of clavicular rotation completely restricts elevation of the arm above 120 degrees which is a serious disability in certain occupations and athletic pursuits.

From their study it becomes apparent that considerable stress is placed on any material used in the repair of the acromioclavicular joint. It is the reason for the frequent breakage of wire which has been used extensively in maintaining reduction. It explains the limitation of motion resulting in the fixation using a lag screw from the clavicle to the coracoid process. This point, however, has been disputed by Kennedy and Cameron.[3]

Over a period of years our group has used various types of repairs and have experienced our share of disappointments in the outcome.

In industrial cases the simplest effective method should be employed. Methods that involve the removal of whole or part of an anatomic structure or the use of materials which can be demonstrated by roentgenograms, such as wires or screws, should be avoided inasmuch as they frequently lead to high disability claims, although clinically the surgeon may believe that he has obtained an excellent result. Likewise surgical scars should be minimized as much as is possible but should not jeopardize an effective repair.

During the past several years we have been employing the use of zytor®, a multifilament braided nylon suture, in the repair of acromioclavicular dislocations. We have also used it repeatedly in tendon repairs, in open reduction of spiral fractures, in maintaining loose bone fragments and bone grafts, and in all of our elective surgical procedures. We have encoun-



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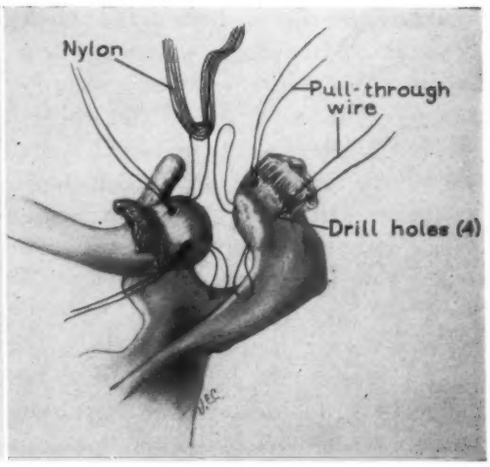

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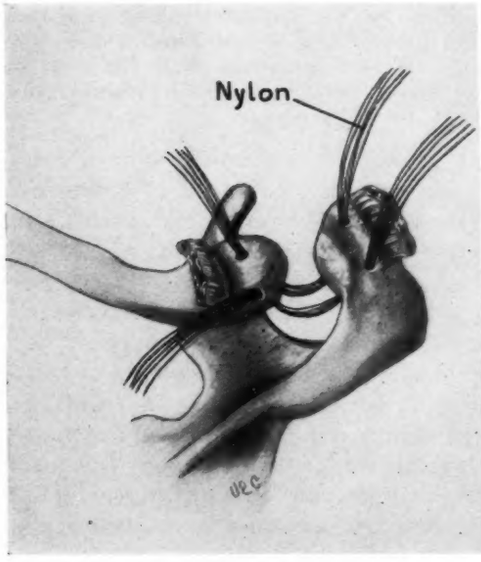
FIG. 1. Illustrates tear of acromioclavicular ligament.

FIG. 2. Drill holes in the clavicle and acromion with pull through wires for inserting the nylon sutures.



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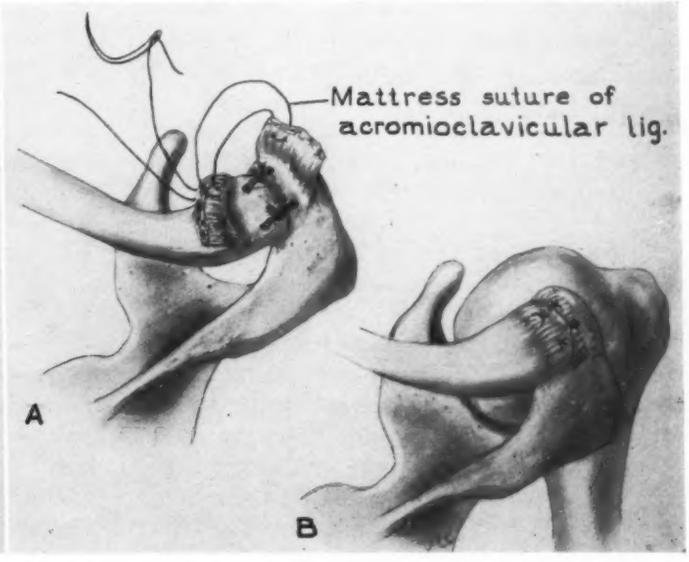

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FIG. 3. Nylon sutures placed.

FIG. 4. A, nylon sutures tied: imbrication of acromioclavicular ligament; B, acromioclavicular repair completed.

tered only one instance of tissue sensitivity which required the removal of the suture. The technic used is as follows (Figs. 1 to 4): a short "saber" incision is made over the acromioclavicular joint. The joint capsule and acromioclavicular ligament are incised transversely and by subperiosteal dissection the outer portion of the clavicle and the proximal portion of the acromion are exposed. Two drill holes are made in the clavicle and also in the acromion approximately ⅛ inch from the joint surface. Pliable guide wires are used to pull the zytor sutures into place. (Fig. 2.) Four to eight strands of No. 0 zytor are used in each suture. The dislocation is then reduced and while it is maintained, the sutures are firmly tied. (Fig. 4, A.) The joint capsule and acromioclavicular ligament are imbricated using single strands of No. 0 zytor. (Fig. 4, B.) The fascia and subcutaneous tissues are closed with No. 000 zytor and the skin with a running suture of stainless steel wire. The operation is performed on a fracture table. Following surgery the patient is immediately placed in a

shoulder spica cast with the arm at 90 degrees of abduction. After three weeks the top of the cast over the arm is removed and upward motions are started. Usually the entire cast is removed by the end of the fourth week.

We have employed this technic since 1949 and believe that we have obtained excellent results with the exception of two cases. One patient tore the suture out of the bone, however the suture did not break. Apparently the drill holes were too close to the articulating surface. A secondary repair using the same technic gave an excellent end result with full function. In the second case some up-riding of the clavicle with anatomic deformity developed but clinically the patient had full function of the shoulder joint without pain and had returned to his occupation as a longshoreman.

A total of thirty-four operations has been performed using this technic, with excellent clinical results.

CONCLUSIONS

Repair of the acromioclavicular joint using zytor, a multifilament braided nylon, is recommended inasmuch as it is a strong suture which does not break easily under repeated rotation of the clavicle.

This type of repair allows a full recovery of function. It is not visualized by roentgenograms which is an advantage in industrial cases.

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Fractures of the Head of the Radius

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FRACTURES of the proximal head of the radius are a rather common injury and, with minor variations in technic, there is rather universal agreement as to the methods of treatment. Fractures are classified anatomically for the most part[1–11] and the type of fracture dictates the treatment. A review of the literature reveals results to be good with standardized treatment in follow-ups of a year.[7] The purpose of this paper is to report the findings in a series of cases followed up for five or more years.

MATERIAL

During the period between July 1, 1946, and December 31, 1948, eighty-four cases of uncomplicated fracture of the proximal head of the radius came under the author's care. Of these, sixty-six were re-examined this year. Excluded from the group are twelve children and thirty-one adults whose cases were complicated by dislocation of the elbow, fractures of the ulna (Monteggia) and penetrating wounds (gunshot, etc.). There were fifty-seven men and nine women, ages nineteen through sixty-nine; mean age was thirty-one. Of the total, forty-two were treated conservatively and twenty-four were resected.

METHOD OF TREATMENT

All cases were seen within forty-eight hours of injury and were treated by a standardized technic. After routine medical and laboratory work-up, the elbow joint was aspirated and a few cubic milliliters of ½ per cent metacaine were instilled into the joint. With relief of pain, an attempt was made to carry the joint through a full range of flexion, extension, pronation and supination (in both flexion and extension). Any bony block to full motion or persistent click in a particular movement was considered a positive indication for resection of the radial head. A full range of motion without clicking or grating was used as a positive indication for conservative therapy with one exception—the presence of loose bony fragments. All comminuted fractures with separation of one or more loose fragments were resected.

Conservative therapy consisted of application of a plaster splint immobilizing the elbow at 90 degrees and forearm in mid-position for ten days. Active shoulder and finger motion were maintained during this period and any recurrence of the hemarthrosis was aspirated during the first week. After ten days, active exercise of the elbow was initiated in a graduated manner: one-half hour in the morning, one-half hour in the afternoon of the first day, etc. Exercises consisted of active flexion, extension, pronation and supination to the extremes just short of pain. No heat, whirlpool or massage were used at any time during the course of treatment.

The splint could usually be discarded during the day in a week but was continued at night for another week. Thus total immobilization was used for the first ten days, partial immobilization for fourteen days. After four weeks, progressive resistance exercises were initiated in all four directions and continued until upper and lower arms were equal in circumference to the opposite side.

At six months each case was evaluated. Those having residual restriction of motion were examined under anesthesia. By this method, restrictions due to soft tissue contracture can be easily differentiated from those due to bony block. Gentle manipulation of the former results in substantial gains in motion, whereas continued attempts to gain motion in the latter by physical therapy is both useless and harmful.

Operative treatment consisted of a direct approach to the radial head between the extensor carpi radialis brevis and extensor digitorum communis. The head was excised just distal to the distal cartilaginous border of the radial notch on the ulna, using an osteotome. The cut end of the radius was treated with bone wax and left uncovered. The fibrillated cartilage

at the site of impact on the capitulum was removed and the wound closed in layers. Postoperative care was exactly the same as with those treated conservatively.

RESULTS

As will be noted in Tables I and II, the results at one year were substantially the same as those at five years in the resected group, whereas some improvement occurred in the middle group in those cases of conservative treatment. This improvement is not considered statistically significant because loss of motion has been rounded to the nearest ten degrees and exact measurements with a goniometer are impossible.

TABLE I
RANGE OF MOTION IN CASES TREATED CONSERVATIVELY AT ONE AND FIVE YEARS

No. of Cases	Flexion	Extension	Pronation	Supination
At One Year				
31	Full	Full	Full	Full
9	Full	Loss 10°	Loss 10°	Loss 10°
2	Loss 10°	Loss 20°	Loss 20°	Loss 20°
At Five or More Years				
38	Full	Full	Full	Full
2	Full	Loss 10°	Loss 10°	Loss 10°
2	Loss 10°	Loss 20°	Loss 20°	Loss 20°

TABLE II
RANGE OF MOTION IN CASES TREATED SURGICALLY AT ONE AND FIVE YEARS

No. Cases	Flexion	Extension	Pronation	Supination
At One Year				
16	Full	Full	Full	Full
5	Full	Loss 10°	Loss 10°	Loss 10°
3	Loss 10°	Loss 20°	Loss 20°	Loss 20°
At Five or More Years				
17	Full	Full	Full	Full
5	Full	Loss 10°	Loss 10°	Loss 10°
2	Loss 10°	Loss 20°	Loss 20°	Loss 20°

The results in the two groups are not comparable for purposes of evaluating conservative and operative treatment as the method of treatment was individually selected as outlined previously.

All cases complained of discomfort in the elbow at sometime or other with weather changes and heavy use of the arm during the first year but at five years there were no complaints in either group when full motion was present and all patients with restricted motion complained of discomfort when attempt was made to carry the joint through full motion.

Of the forty-two cases treated conservatively, twelve were manipulated at six months and ten maintained the increased range of motion obtained. In the resected group, six were manipulated and all six maintained the increased motion.

Radiographs at five or more years when compared with those at one year showed little change. There was no evidence of a progressive arthritis and in none did an osteochondritis of the capitulum develop. Five of the resected cases and one of the conservatively treated cases showed calcification along the collateral ligaments. All had appeared at one year and all had some restriction of motion.

None of the patients treated conservatively developed myositis ossificans. In one of the resected cases there was ossification on the flexor aspect of the radial neck but this reabsorbed without any particular treatment and had completely disappeared at one year. This case obtained full motion.

Seven of the resected cases showed some irregular calcification or ossification in the space formerly occupied by the head of the radius. This did not seem to affect function as five patients had a full range of motion. All of the patients resumed their former occupations which included seamen, postal carriers and clerks, welders, longshoremen, ship fitters, etc.

COMMENTS

From this rather small series of cases, it would appear that one year is a sufficient length of time to evaluate the results of treatment of fractures of the head of the radius. At six months a significant number with restricted motion can be assisted by manipulation under anesthesia.

It is believed that an anatomic classification of fractures for purposes of deciding the treat-

ment is unreliable. The amount of damage to the radial head seen at operation usually far exceeds that demonstrable on a radiograph. Furthermore, a bony block to full motion can exist with no radiographic evidence of displacement of the fracture. On the other hand, a full range of motion and perfect function are possible with significant deformity of the radial head. A test of function immediately after injury as outlined provides a dependable indication for the proper method of treatment.

On resecting the head of the radius enough must be removed to allow the neck to clear the radial notch on the ulna or a bony block will result in limited pronation and supination. If the cut end of the neck is covered, a great deal of care must be exercised not to involve the annular ligament in the suture or to pull the synovial cuff from between the neck and this ligament. I have never been able to identify the "posterolateral continuation of the quadrate ligament," named the "ligamentum capituli radii" by Jacobs[7] which he uses to cover the neck. Redundant folds of synovium are available to purse-string over the neck; but if one tests such a repair at the time of surgery by putting the joint through full motion, the synovium invariably pulls away. The use of bone wax probably does nothing more than limit the postoperative hematoma. In any event, covering the neck does not appear to be an essential part of the surgery. The use of a Gigli saw to resect the head should be condemned as it distributes bone dust throughout the wound and favors postoperative ossification of the hematoma.

SUMMARY

A series of sixty-six cases of fracture of the radial head have been followed five or more years. A method of determining whether to resect the head of the radius or treat the fracture conservatively has been outlined.

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DISCUSSION OF PAPERS BY DRS. DORGAN, NEER, McCONVILLE, BUCKNER AND CALLAHAN, AND WAGNER

James Keane Stack (Chicago, Ill.): Dr. Mazet brought out a subject that is very dear to my heart, and to Dr. Magnuson, and we feel that that procedure is a fundamentally sound one. In 1938, before the Chicago Surgical Society, we gave a paper illustrating the failure in 18 per cent of our cases of the suspension operation using the biceps tendon after the manner of Coler, and we felt that that rate of failure was too high.

Since 1938, we have not performed that operation, and on the basis of anatomic studies which we made and on the basis of the thought that at no time in the operating room was the shoulder exposed, and the whole front of it wide open, we have never been able to dislocate the shoulder using the same trivial mechanism that the patient told us of.

Sure you can dislocate a shoulder in the operating room; but when somebody comes in and says to you, "I was sitting at my desk last night, and I reached over here for a book and my shoulder came out of place," and then you put his arm in that same position in the operating room and it doesn't come out of place until you get your fist behind his shoulder and pry it out of place, then that, to me, is a strong suggestion that this whole thing is based on the asynergistic action of muscle, rather than the presence of an anatomic or destructive defect.

Dr. Mazet* has a wonderful series of cases. He has twice as many as we have. De Palma has more than we have. There is a man who practices in Melbourne with whom I correspond who has even more than this.

We have two patients with a redislocation. One is a fellow that Tom Quigley took care of at the Peter Bent Brigham Hospital, who fell off a polo

* Dr. Mazet presented a film on subscapularis transplant operation for recurrent dislocation of the shoulder.

pony. The other is a girl from Dubuque, Iowa, who was also involved in a horse accident. Shoulders can be dislocated, either before or after operation, if the proper forces are applied in the proper ways.

If I may just emphasize one point that Dr. Neer brought out: the indiscriminate use of the prosthetic device in the shoulder won't take hold as it has in the hip—there is no fracture in the body certainly where there is such a discrepancy between the anatomic and functioning result. I am sure you will agree that you can have the most awful looking x-rays you ever saw involving the surgical neck of the humerus, and yet have perfectly wonderful function. Let us not forget that that still obtains, and that there will be relatively few people who will require help in the way that Dr. Neer has demonstrated.

Dr. Wagner always comes up with something fundamental and long-range. I cannot help but remember his beautiful paper two years ago in Chicago when he discussed the long-range follow-up of fractures of proximal pole of the navicular bone. What happens to these people as time goes on? That is what we want to know.

I would like to ask Dr. Wagner just one question. We are plagued, it seems, in this radial head business by people who have pain in the wrist, and I should like to ask him if that isn't his experience too. What does he do about it? How do the patients fare as time goes on, and so on?

MORGAN COLBERT (Louisville, Ky.): I think we are all agreed that we have heard extremely sound reasoning with regard to these resections of various portions of bone. I would like to make a few comments which may not have been emphasized.

Someone mentioned the question of pain at the wrist where we have resected the head of the radius. I personally have been plagued with this complication, so that I am leaning back toward more conservative management in this fracture.

In the scapular resection, all or part, one must remember that the scapular, of course, is the only stabilizing structure between the trunk and the extremity, and we lose something when we resect any part of it. We have all done so. There are certain indications. But I believe we lose a very significant bit of power in this procedure.

I think this discussion is not complete without a re-emphasis of a long-term follow-up in all these cases; in other words, five years or more. In the final comment, I think we will some day, perhaps, have the answer to the question of power loss weighed against motion, both of them weighed against pain.

One other comment about the acromioclavicular separation. I certainly find that most of these that we see have very little pain. There are a few that would appear to require operative intervention.

KELLOGG SPEED (Highland Park, Ill.): Discussing treatment of posterior dislocations at the shoulder in a textbook on fractures and dislocations I stated, "If there is complicating pathology involving fractures of the tuberosity or glenoid rim or muscle laceration, reduction may be incomplete, and if function is interfered with, open operation may be indicated. One must consider carefully the possibility of permanent cure before operating on epileptic or paralytic patients, who lack muscle tone. The use of posterior bone abutments employing transplants from the tibia may be required."

In advocating a bone transplant block operation to avoid recurrent posterior dislocation, the fate of the guarding cartilaginous glenoid rim, avulsed, split or fractured off, was always a mystery. Our knowledge of union here is almost nil since, recently, so few patients were operated upon and none ever went to autopsy. Bone transplant operation was suggested as a restoration of this type with believed persisting disorder involving failure of union of this rim.

The subject aroused international interest and in February, 1954, I received an inquiry from my friend Stuart Scougall, M.D., of Sydney, Australia, seeking experimental help to solve the problem of doubt about the occurrence of primary union, where the labrum glenoidale is sheared off (in posterior dislocation). He suggested shearing off the labrum with a chisel and/or slitting it longitudinally without complete detachment to see if it would reunite, feeling that the work could be done on the labrum posteriorly where easily accessible in monkeys and that the result should apply anteriorly.

I perfected arrangements with Dr. Vernon Luck of Los Angeles, California, who supplied the Rhesus monkey, operating facilities and after-care for this experiment; together we operated upon a young active monkey in March, 1954, to cause these defects. The animal made proper recovery. Arthrograms were made after eight weeks. The monkey was then sacrificed; the shoulder specimens were obtained and shipped without disturbing their gross relations to Dr. Scougall, who then x-rayed and sectioned the material in complete examination.

Dr. Scougall's paper was read August 14, 1954, before the A.O.A. in Australia. He tells me that he obtained excellent slides of the histology of the shoulder areas operated upon and that there was no break in the histologic continuity of the structures. In addition, before section there was no doubt about the firmness macroscopically of junction of the labra and glenoid operated upon, whether split or completely fractured off. Arthrograms showed no extra-articular extrusion.

We might gather from this that labrum injuries in man probably heal promptly and completely, that a bone block operation is not really indicated

to supplement any deficiency considered to be set up by lack of the cartilaginous rim support and that, if used, such a transplant becomes merely a temporary mechanical block which prevents recurrent dislocation and gives the capsular, plus muscle insertion tears, an opportunity for firm lasting healing, thus leading to cure. I have roentgenograms of one patient with well placed bone transplant block in position who suffered no recurrence. Twenty-five years after operation roentgenogram showed all transplanted bone absorbed and no trace of its insertion or lasting quality. This would be in accordance with Wolff's law.

I believe many of these points apply directly to the much used Bankhart operation.

FRANK E. STINCHFIELD (New York, N. Y.): Modesty, honesty and superior ability are attributes we would all like to possess. Dr. Neer does, I can assure you. He has reviewed all of these cases very carefully. I, personally, have seen ten of his patients and think that his results, which he has shown, are due to three factors: First, his uncompromising care in defining the indications and contraindications. There is no prosthesis put in any shoulder at the Presbyterian Medical Center without Dr. Neer's approval. Secondly, we are dealing with entirely different mechanics than in the hip joint. Dr. Neer's point of leaving the greater tuberosity with the rotator cuff intact and just replacing the articular surface is a most essential point in the entire procedure. Thirdly, it is not a weight-bearing joint and for that reason I believe the results are going to be quite different than those in hip prostheses.

It is strongly recommended that everyone read his published paper because in it he emphasizes a most meticulous dissection and careful insertion of the prosthesis.

It is my belief that we are going to see more of these prostheses used. I agree with Dr. Stack that they should not be inserted indiscriminately. However, when the indications are right it is a most useful and gratifying procedure.

JAMES J. CALLAHAN (closing): Dr. Dorgan's paper, I thought, was very excellent. There are two points that I would like to discuss.

First, he stated the treatment of posterior dislocation was the same or similar to treatment of an anterior dislocation. The usual treatment for anterior dislocations is to place the arm across the chest, and if this form of treatment is employed, it has been my experience that the posterior dislocation will recur.

Second, I offer the Claremont operation; this is an operation used for anterior dislocations of the shoulder, which makes an excellent procedure for posterior dislocations because it reinforces the weak area of the posterior portion of the shoulder.

I also enjoyed Dr. Mazet's film. In addition I would like to offer this suggestion, I believe that the operation he performs is excellent but there is one point that has not been stressed in recurrent dislocations of the shoulders, and we have experienced this in all of them, and that is, there is a marked relaxation of the supra and infraspinatus and teres minor tendons. This looseness permits a redislocation or subluxation with any type of repair for habitual dislocations, and unless the supra and infraspinatus and teres minor are shortened at the time of surgery, a suspension operation, or subscapularis repair of any type of procedure will not be successful.

ARTHUR L. MURPHY (Nova Scotia, Canada): Just one short point about wrist pain in injuries to the radial head: I realize there are many causes. I think it is important that we should recognize one which can be missed even by some of us who pay more attention to traumatic than to other branches of surgery; and that is the fractured scaphoid.

The same mechanism, the fall on the outstretched hand, which commonly produces the fracture of the radial head, also produces the fracture of the scaphoid. It is so very, very easy to miss it. I think the wrist should always be x-rayed for scaphoid injury with the radial head fracture, not only at the time of the accident, but a week or two later.

PRESTON A. WADE (New York, N. Y.): I would like very much to discuss Dr. Neer's paper and to compliment him on a very fine presentation and contribution to the surgery of trauma.

I would like to call your attention to the fact that he has emphasized that all fractures of the head of the humerus are not to be replaced by a prosthesis and that these prostheses are reserved for only certain types of cases.

He has mentioned several indications and I would like to add another indication, as a result of a case which came under my care in March, 1953.

This fifty-five year old man had hypernephroma and a solitary metastasis in the upper end of the right humerus. His first symptom was that of pain in the shoulder; and while he was being investigated in the hospital, he sustained a pathologic fracture through the metastasis in the shaft of the humerus. A biopsy was done and hypernephroma found, but retrograde studies of the kidneys did not show evidence of tumor in either kidney.

The upper end of the humerus was resected and a long vitallium® prosthesis with an intramedullary rod was inserted in place of the excised portion of the bone. Much of the musculotendinous cuff of the shoulder had to be sacrificed and the cut ends of the muscle were sutured to the prosthesis.

This man made an uneventful recovery and his hypernephroma was discovered in the right kidney as the result of an aortogram and the right kidney was removed with the primary tumor.

Since resection of the humerus, no other metastases have developed. There is considerable limitation of motion of the shoulder joint, there being only thirty-five degrees abduction, and that is all, of course, scapulohumeral motion. However, he has good function in his forearm and elbow and is carrying on his work as a construction engineer. I, therefore, believe that resection of a portion of the humerus for tumor is another indication for the prosthesis.

EDWARD C. HOLMBLAD (Chicago, Ill.): I have enjoyed these papers very much and would like to comment on two of them.

On acromioclavicular joint separation, I would like to suggest that in medicolegal cases, a very excellent film can be obtained for use in court by having a 7 by 17 or 14 by 17 film placed in horizontal position and the patient in the standing position. Now you have a comparison of both shoulders, acromioclavicular joints, on the same film which makes for a very nice demonstration for medicolegal purposes, or for file information.

I want to comment briefly on Dr. Wagner's paper on resection of the head of the radius. I think this is an excellent procedure. In the early part of his presentation, I believe, he mentioned the fact that a cast was applied for three weeks to what I saw to be a simple impacted fracture of the head of the radius.

We believe that early mobilization of fractures is indicated especially without much displacement, on the theory that if the original trauma was not sufficient to displace these fragments, that subsequent movements, subsequent passive and active motion, will not displace these fragments and will not interfere with healing. So we do not apply plaster of paris casts to this type of fracture to the head of the radius. We feel that they should be put at rest.

The only indication for applying plaster to that type of fracture, in our experience, has been to relieve pain. We will use it for that purpose, in transporting a patient, for instance. But if a person has such a fracture, we would simply put it up with sheet wadding, elastic bandage and sling, and start early active and passive motion as fast as the patient can tolerate it, and we use the degree of pain as the guide to what is comfortable mobility. We firmly believe that early mobilization of fracture without displacement is indicated.

RONALD W. ADAMS (Boston, Mass.): In the absence of Dr. Gordon Morrison, I would like to say a word about Dr. Dorgan's paper.

Dr. Dorgan deserves the credit for our interest in the subject at the Boston City Hospital. I think that before two years ago, we were not too much aware of this particular lesion; at least we saw it so seldom that we were not on the lookout for it and because of Dr. Dorgan's interest in the subject, we have found many cases over the last eighteen months, as he has told you.

I think it is probably more than local pride that makes us particularly recommend the Maloney line as a diagnostic feature for picking up these injuries, and we would therefore recommend it to you for your evaluation when you return to your practices.

ROBERT H. KENNEDY (New York, N. Y.): Just a suggestion about the acromioclavicular separations which I have not heard mentioned. I feel strongly that there are few cases which require operative intervention, that these should all be treated conservatively with an attempt to obtain repair of the ligaments; that the persons should then be returned to work, if they are working men, and that they should have at least a three-month trial of doing their regular work before one takes out the outer portion of the clavicle. We have seen too many who have come in years afterward who are longshoremen or truck drivers who have to do heavy lifting in which the clavicle rides up 2 inches, and they have no complaints whatsoever.

I think we should not take the clavicle out until the person has had a chance for work therapy to see how much he complains. If he does not care to work with his clavicle riding up, he may not care to work again after the outer end of the clavicle has been taken out either.

H. FRED MOSELEY (Montreal, Canada): I wish to thank the Committee who have arranged and the speakers who have covered the subject of the shoulder so thoroughly. There is only one point on which I would like to concentrate and that is the excellent follow-up of Dr. Mazet. I think his objectivity and his honesty are to be commended. However, I think that his motion picture demonstrating his results with this operation indicates that it does not really give the satisfactory results which we would expect from any operation for recurrent dislocation of the shoulder.

In his technic he shows, too, the torn glenoid labrum very visible in the wound, but he does nothing about it. I would say that is a direct criticism of the method. He mentions that there are six cases of recurrent dislocation after the operation, which is a reasonable recurrence rate; but he also states that there are seven patients who have a feeling of instability. This feeling of instability is a problem which I have studied and it is due to the instability of the fulcrum of the humeral head on the glenoid fossa.

I would like to suggest that at the time of reoperation on these patients that a method I have used of studying the joint capacity of these shoulders be employed. It is perfectly simple. At the time of the operation, when the capsule and subscapularis are exposed, a needle is inserted into the joint, and the capacity of the joint is studied. We

have done this on the normal shoulder and in recurrent cases. We find that in those cases that have recurrent dislocation, the common denominator is the fact that the joint capacity is two or three times that of the normal shoulder.

In these cases that have instability, you will find that the joint capacity is abnormal, and the degree of instability varies with the degree of increase of joint capacity.

JOSEPH A. DORGAN (closing): I would like to thank Dr. Speed for his comments. I believe he was overly kind in the absence of Dr. Morrison.

As far as the bone blocks are concerned, I, myself, have had no personal experience with the application of bone blocks of posterior dislocations of the shoulder. I have talked with people who have done it, and in all instances the results have been satisfactory.

Whether this, as Dr. Speed suggests, merely serves as some temporary method which allows a bony block until the soft tissues can take up the slack and prevent posterior dislocation or not, I cannot say.

In cases of recurrent dislocation, chronic recurrent dislocations which they have had, without a defect in the head, the operation of choice has been a transposition anteriorly and interiorly of the infraspinatus and teres minor muscles comparable to the subscapularis transplant. If there is a defect in the anteromedial aspect of the head, I believe a bone block would be of value.

As far as Dr. Callahan's remarks are concerned, we have found that in the posterior dislocations, that merely by putting the arm by the side after reduction, the reduction has been stable. Dr. Giannestras has reported a case in which mobilization in external rotation had been necessary because when the arm was put by the side on internal rotation, the dislocation occurred. I believe that that would be an indication for operation. I have had no experience with the Claremont operation.

ROBERT MAZET (Los Angeles, Calif.): Perhaps we use the far distance of the West and cannot see what is right in front of our nose, but maybe it is the smog; I don't know.

I am quite interested in the comments here with regard to this matter of pathologic conditions of the shoulder, particularly the relaxation of the rotator cuff, and also the mention of the measurements. We have noticed in these cases all sorts of lesions. We have noticed some knocked shoulders, some tears in the capsule, and we have in some instances seen this relaxation of the capsule.

We haven't paid any particular attention to them. I mean we have gone ahead by the same operative procedure and, of course, this does tighten up a lot of these structures. We haven't attempted to tighten up the muscles of the rotator cuff. Maybe we ought to do that. I just don't know.

I want to thank the discussers for drawing our attention to it and we will look into it a little bit from now on.

CHARLES S. NEER, II (closing): Relatively few people require a replacement in the shoulder. I am glad that Dr. Wade, Dr. Stack and everyone who commented on this paper have emphasized that point. Most fractures of the shoulder can be treated by discarding the x-ray pictures and working for function. It is very tempting to use a new operative procedure. Several French authors describe treatment with a Judet prosthesis for surgical neck fracture. This is inexcusable and serves as a warning as to what might happen here in the future.

The second thing I would like to say refers to Dr. Stinchfield's mention of technic. A few years ago, I saw an exhibition opposing the use of plates in fractures. There was not one case shown that had been plated properly. Murray, in his description of how to do bone plating, emphasized that there were three requirements: first, a good place to do the operation, a properly equipped operating room; second, proper assistance and, finally, a qualified surgeon. I think these are the prerequisites of any major operation, and certainly it is not a simple matter to do a repair of a comminuted fracture dislocation. The inexperienced would be quite lost.

B. E. MCCONVILLE (closing): Dr. Holmblad mentioned that both shoulders should be x-rayed, and I certainly agree with that. Here* is an x-ray of both shoulders with an excision of the outer clavicle. The case is five years old and is not one of ours. This patient not only had loss of power but also loss of function, so not all of these cases turn out 100 per cent.

I would like to agree with Dr. Kennedy with regard to conservative management. We have seen, all of us, any number of patients that have come into the office, particularly football players, with marked prominence of the acromioclavicular joints. I feel that this marked prominence is due to repeated separations that have gone on to healing without treatment, and I am sure that there are any number of patients with this type of case who have had no treatment and have perfectly normal-functioning shoulders without disability. So, I think that some judgment should be used in your cases.

I also want to thank Dr. Murphy for his remarks. The Kirschner wire technic of stabilization of the joint is an excellent one; and if it is properly performed, it gives a very good result.

I think that some of the percentages that I

* Dr. McConville presented a slide to illustrate his discussion.

mentioned, which the literature states are 20 per cent poor results from conservative treatment, certainly do not apply to the Kirschner wire technic, although some poor results may be had from this method. I have had them. It may be that I did not get the wires placed properly.

There is a certain degree of danger in placing Kirschner wires that we all should be aware of, and I think all of us are. I have tried using a long screw through the acromioclavicular joint and felt that it worked fairly well. I think, however, that nylon is just about as easy a method and, so far, has given very satisfactory results.

CARRUTH J. WAGNER (closing): I wish to thank Dr. Stack and Dr. Holmblad for their comments, and I think I can answer both of them at the same time.

As far as pain of the wrist is concerned, I think that it is connected with the subluxation of the distal radial ulnar joint that takes place at the time of the fracture. For this reason, I think immobilization is important, because when the cast is removed in ten days to two weeks, the pain in the wrist has disappeared.

Another justification for casting, in my hands, is that the type of case we see must be treated a little differently from that in private practice. Furthermore, in setting up a trauma department in a Service Hospital you have to "spell out" the treatment. You have to make it a routine rather than an individualized treatment. I am sure in private practice you can treat each case individually, supervise it and probably get by without any mobilization in most cases. Putting it the other way, I do not think immobilization interferes with function if it is not unduly prolonged and is combined with normal finger and shoulder exercise.

After ten days these patients are taken out a half hour in the morning and a half hour in the afternoon and started on active exercise using pain as a guide. By the end of three weeks, one can introduce resistance exercises. The amount of motion that you have in three weeks, will equal that which you have when you start them on early motion without immobilization.

In my experience fractures of the carpal navicular are extremely rare when the proximal head of the radius is fractured. I can think of only one case in my experience when both fractures occurred together. We routinely radiograph the wrist in proximal radial head fractures.

End Results in Suction Socket Prosthesis for Above-knee Amputees

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From the Departments of Medicine and Surgery, Veterans Administration. Reviewed by the Veterans Administration and published with the approval of the Chief Medical Director. The statements made and the conclusions drawn by the author represent individual opinion and do not necessarily reflect the opinion or policy of the Veterans Administration.

OVER a period of seven years there has been a large program of prescription, fabrication and fitting of the suction socket artificial limb for above-knee amputees. One interim[1] and one final[2] report have been published describing in detail this expansive program including the necessary education of surgeons and limbfitters in the special requirements and technics necessary to obtain satisfactory results. The first report reviewed 211 cases, the second 606. The Veterans Administration program records that experience in its thirty Orthopedic and Prosthetic Appliance Clinics, located in Medical Centers where the concentration of leg amputees was greater than 150. This third report will cover experience with 2,184 cases. It was most important to insist that this type of limb be tested in a variety of geographic locations under varied climatic conditions. (Fig. 1.)

Any analysis of end results (Table 1), particularly when inclusive of 2,184 cases and collected from the material of thirty clinical investigators, must of necessity be looked upon with some doubts as to errors or differences in interpretation of success or failure. However, an average of 15.7 per cent failures under the circumstances reveals that almost 85 per cent of over 2,000 above-knee amputees are still wearing the suction socket. That so large a group in seven years has continued to use this type of artificial leg is a most favorable factor.

However, if one is to present an end result study, the only benefit is to point out the reasons for failure in order that in the future certain pitfalls may be avoided. This experience within the Veterans Administration, therefore, can be of benefit to others. There is no question but that this program has resulted in a better understanding by surgeon, prosthetist, physical therapist and all members of the prosthetic team of the need to pay greater attention to the finest details of fit and alignment in the prescription, fabricating and inspection of all artificial above-knee legs. As Alldredge and Murphy have so ably pointed out: "With the suction socket in correct alignment, the amputee balances his weight completely on the leg, since he has no pelvic band and (steel) hip joint to lean against."[3] (Fig. 2.)

TABLE 1
VETERANS ADMINISTRATION SUCTION SOCKET STUDY—1954

Clinic Team Location	Reported Veterans	Failures		No. of Successful Cases
		Number	Per cent	
Atlanta	26	15	57.6	11
Boston	63	31	49.2	32
Buffalo	11	3	27.2	8
Chicago	238	20	8.4	218
Cincinnati	68	7	10.3	61
Cleveland	180	10	5.5	170
Dallas	137	6	4.3	131
Denver	6	1	16.6	5
Des Moines	40	8	20.0	32
Detroit	156	19	12.1	137
Honolulu	18	1	5.5	17
Kansas City	25	6	24.0	19
Los Angeles	200	8	4.0	192
Louisville	57	14	24.5	43
Nashville	43	7	16.2	36
Newark	40	9	22.5	31
New Orleans	30	4	13.3	26
New York	72	26	36.1	46
Oklahoma City	18	4	22.2	14
Philadelphia	187	20	10.6	167
Pittsburgh	48	12	25.0	36
Portland, Oregon	39	7	17.9	32
Salt Lake City	35	17	48.5	18
San Antonio	40	7	17.5	33
San Diego*	17	6	35.5	11
San Francisco	185	54	29.2	131
Seattle	47	5	10.6	42
St. Louis	59	8	13.5	51
St. Paul	63	4	6.3	59
Washington, D. C.	36	4	11.1	32
Total	2,184	343	15.7%	1,841

* No longer in operation.

In analyzing the 15.7 per cent (343) failures in this series it is recognized that the greatest number occurred in the early stages of this program (when, incidentally, contraindications were deliberately tested), and that as the surgeon and prosthetist gained in experience and those five clinics having a failure incidence exceeding 30 per cent and an average incidence of 44.6 per cent (about three times the average for *all* clinics), accounted for 27.7 per cent of the total failures while supervising only 213 or 9.7 per cent of the total cases. (Table III.)

FIG. 1. Geographic location of orthopedic and prosthetic clinic teams.

judgment, the percentage of failures generally decreased. It has been the experience of seven clinic teams, each of which fitted more than 135 cases that their failures represent an incidence of only 10.7 per cent (in a total of 1,283 cases, approximately 60 per cent of the total series). In contrast, eight clinic teams each having an experience limited to thirty or less cases incurred an incidence of failure of 26.4 per cent. (Table II.)

This remarkable variation undoubtedly depends on many circumstances, some very difficult to control. In general, though, following formal training of surgeons and prosthetists, patient perseverance in overcoming inevitable initial difficulties leads to the attainment of skill, wisdom and confidence. These in turn lead to wiser selection, better and more rapid initial fitting, fewer revisions and less strain on the motivation of the patient. Judgment is

TABLE II
END RESULTS DEPEND ON EXPERIENCE

No. of Clinics	Total Cases	Incidence of Failures
7 clinics with 135 or more cases each.....	1,283 (58.7%)	10.7%
8 clinics with 30 or less cases each.....	151 (6.9%)	26.4%

TABLE III
END RESULTS VARY

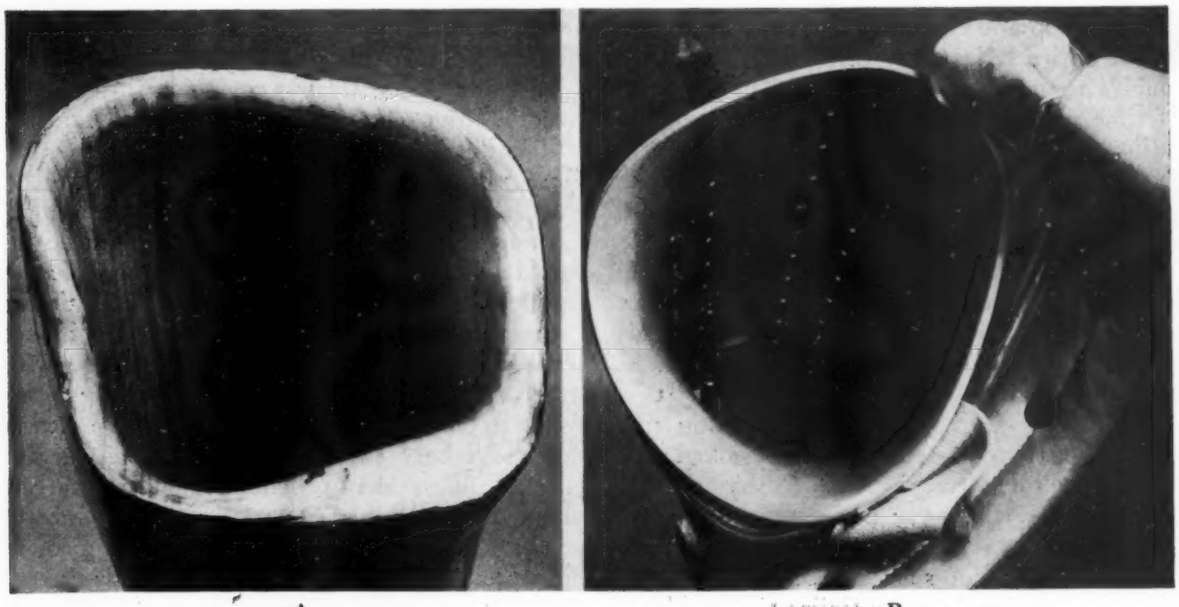
No. of Clinics	Total Cases	Incidence of Failures
6 clinics with lowest incidence of failures.....	836 (38.3%)	5.9%
5 clinics with highest incidence of failures.....	213 (9.7%)	44.6%

From another viewpoint the six clinics with lowest incidence of failure supervised 836 cases or 38.3 per cent of the total with an incidence of only 5.9 per cent failure, approximately one-third the national average. In contrast, gained by evaluating results. In some cases of failure, it appears that common errors were made early in the program by the prescribing surgeon in the selection of cases. In some few clinics deliberate experiments were made in

fitting difficult cases. Thus it would appear that contraindications could be defined more sharply and information of value in fitting these cases, or rejecting them for this type of prosthesis, could be carefully studied and evaluated.

The successful suction socket amputee must have (1) a well muscled and contoured stump. Firm muscles and a minimum of fat will simplify the process of obtaining a good fit (Fig. 3) and will minimize the number of adjustments needed to maintain an accurately fitting socket. Strong muscles are needed to control the new found freedom of hip action. In addition, the actively contracted muscles increase the circumference of the stump causing tight contact with the wall of the socket, assisting the stump to carry the prosthesis and reducing the negative pressure generated during the swing phase. The selected amputee must (2) reside in an area conveniently located to the limb shop for multiple check-up and socket adjustments during the first six months' trial of the socket. He must (3) have employment from which he can obtain leave to visit this shop and the clinic at frequent intervals and (4) he must be motivated to devote the time necessary for gait training with this new prosthesis. There are, therefore, four fundamental requirements to be met prior to the surgeon's prescription of a suction socket limb for an above-knee amputation. The absence of any one of these four criteria can produce failure. There is no question but that in the enthusiasm of utilizing a new device, many of our clinics prescribed without satisfying all criteria. There is one failure on record in which

FIG. 2. Left, conventional above-knee limb. Right, suction socket above-knee limb.



3A 3B

FIG. 3. A, suction socket. B, conventional "plug type" socket.

FIG. 4. Silesian type belt.

a suction socket prosthesis was prescribed for an amputee residing 400 miles away from the nearest shop and clinic. Among the 343 failures in the entire series forty-three were attributed chiefly to inconvenience and substantial loss of time on the job due to frequent fittings or adjustments, and sixty-three were reported as inadequately motivated to adjust themselves to a new type of prosthesis—almost one-third of the failures.

Certain physical factors bear upon successful prescription of a suction socket for above-knee amputations. The patient should maintain his body weight during the six-month period he is undergoing adjustments and training. It is important to keep in mind that during this period the stump musculature is physiologically undergoing hypertrophy. A flabby stump, formerly only passively utilized, is being developed into an active agent of locomotion. Keeping the suction socket in accurate fit with a gain in body weight multiplies the problems of fit and alignment. Conversely, a loss in body weight produces a shrinkage of the stump and the frequent complaint of "loss of suction," often uncorrectible to the patient's needs. There were twenty-two failures chiefly attributable to body-weight gain or loss resulting in changes in circumference of the stump. Other physical factors accounting for failures were due to poor shape or fit of the socket resulting in a choking of the stump, circulatory edema and dermatosis at the distal end of the stump. Incorrect shape and poor fit were reported in twenty-six cases of failure. Loss of suction, usually caused by poor shape or fit, accounted for an additional forty failures while a "feeling of insecurity" was reported in twenty cases—less than one-third of the total failures.

TABLE IV

SOME CAUSES OF FAILURE IN 343 CASES REPORTED

1. Skin allergy or skin disease
2. Initial selection of poor risks
3. Inadequate motivation
4. Loss of suction
5. Poor fit and alignment
6. Gain or loss in body weight
7. Feeling of insecurity
8. Excessive perspiration
9. Miscellaneous

Skin diseases, the result of friction or sebaceous glands producing cystic degeneration and furunculosis together with certain allergic reactions, have been reported 101 times. Often these are aggravated or even caused by poor fit and alignment or by improper finish of the socket wall. Still other causes of failure have been reported in Buerger's disease or by the extra problems of triple amputees and double leg amputees, etc., in twenty-eight instances—more than one-third of the total failures. (Table IV.)

Any analysis of failure must suggest remedy by which improved results can be obtained. From the data presented in this series it is obvious that errors made were largely due to poor selection of cases in the light of all the requirements as now understood. It is not possible to anticipate 100 per cent success with the prescription, fabrication and training necessary to obtain satisfactory results in the fitting of above-knee amputations. Since the suction socket offers many benefits, some surgeons believe they are justified in trying it in doubtful cases. On the other hand, its failure in such instances, if promptly recognized, leads merely to easy conversion to a pelvic-band limb. The fabrication technics are particularly important

not only in the fitting of a socket but also in its alignment on the knee, shank, ankle and foot.[4] The proper selection of amputees to be fitted is to be emphasized as the first step. The team approach as described earlier is essential.[2] The salvage of a prolonged failure is very difficult; therefore the utmost care must be directed toward proper selection and prescription of cases. Perhaps if more belts of the Silesian type (Fig. 4) had been properly prescribed and fabricated, we might have been spared some of our failures.

The limb industry has reported (Table v) upon its results in 5,882 cases fitted in seventy-two shops throughout the country. If cases "converted to conventional prosthesis" (7.8 per cent) and "complete failures" (5.1 per cent) are combined, the total of 12.9 per cent does not differ greatly from the 15.7 per cent failures in the presently reported series from Veterans Administration Clinics. (A very large fraction of our 2,184 clinic cases is undoubtedly included among those reported by the limb makers, who almost universally hold Veterans Administration contracts.) The over-all failure incidence of only 4.3 per cent in 1949[1] neglected many cases who were alternately wearing suction sockets and conventional prostheses. The reports of failures of 17 per cent in 1950,[2] 15.7 per cent in the presently reported 1954 survey and 12.9 per cent from the limb industry in 1954 (Table v) indicate a reasonable stability and a slow decrease with increasing numbers. With increasing experience and skill, *freshly* selected and fitted cases should show the low incidence of failures corresponding to the six most successful clinics.

In conclusion, it may be stated that analysis of the end results of the suction socket prosthesis reveals that the incidence of failure is not more than 15.7 per cent in a series of over 2,000 cases prescribed and fitted in thirty medical centers. A critical analysis of the causes of failure is presented and criteria for more careful selection of cases for prescription and fitting is presented. It is believed the incidence of failure may be reduced to that of 5.9 per cent, the experience reported in the Veterans Administration's six most successful Orthopedic and Prosthetic Appliance Clinics.

TABLE V
AMPUTEE ACCEPTANCE OF THE ABOVE-KNEE SUCTION SOCKET*

Year	1948†	1949‡	1954§
Limb shops reporting	10	79	72
Total cases fitted:	52	1,262	5,882
Men	52	1,047	4,616
Women		170	912
Children		45	354
Gritti-Stokes		112	250
Fitted with auxiliary supports		149	1,539
Converted to conventional prosthesis		46 (3.6%)‖	461 (7.8%)‖
Complete failures	6 (11.5%)	56 (4.4%)‖	301 (5.1%)‖

* Haddan and Thomas (Artificial Limbs, May 1954, page 31).
† Data from the University of California (18).
‡ Data from OALMA's national survey on suction sockets, 1949; reported in The OALMA Journal (11).
§ Data from OALMA's 1954 national survey on suction sockets.
‖ In this table classification of results is different than that in the VA Clinic series where all cases converted to conventional limbs would be classed as failures. Adding these to total failures would make 102 (1949) 8% and 762 (1954) 12.9%.

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The Rehabilitation and the Re-employment Potential of the Amputee

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REHABILITATION of the amputee begins with the onset of the illness or the injury which leads to the necessity of major amputation. Quite obviously, the primary goal is to avoid the necessity for amputation whenever possible. However, the injury or the disease may be of such severity that, in order to save life, the patient's limb must be sacrificed. Wherever conditions permit, it is highly desirable that the patient be informed of the likelihood of prosthetic fitting following the amputation, and that this information come from the surgeon who is amputating the arm or the leg. If, during the early postoperative period, it is possible to have a person who has suffered a similar amputation and has successfully learned to use an adequate prosthesis come and visit the patient, the acquaintance with a successful prosthetic wearer does more to bolster the morale of a new amputee than many hours of conversation. The earlier the concept of functional restoration can be introduced into the patient's thinking, the more effective will be the ultimate rehabilitation.

It is not within the purview of this paper to consider the matter of site of election for various amputations; this is a surgical problem.

Adequate postoperative care of the amputation stump demands more than good aseptic technic. (1) Proper stump bandaging to encourage a conical stump is essential for proper fitting of any prosthesis of a truly functional nature. (2) The range of motion, both active and passive, to maintain the fullest possible mobility in the joints remaining in the extremity is most important if the amputee is to be successfully fitted with a good prosthetic device. For example: it is far easier to prevent a hip flexion contracture in an above-knee amputation than to try to overcome a well developed hip flexion contracture six months or more later. The same is true for above-elbow amputations when considering mobility of the shoulder joint. Early active motion in below-elbow amputees to maintain not only flexion and extension of the elbow but also rotation of the forearm, is highly desirable. Simple instructions to the nursing staff and to the patient regarding active motion will help. It has been our experience that painful stumps are frequently less painful when early motion is possible and is encouraged, and frequently so-called "phantom limb" pain is relieved as the patient becomes more active with the stump. (3) Stump toughening measures, such as pushing and eventually banging the bandaged stump against pillows, foam mattresses and harder objects, are also exceedingly useful in the early postoperative period and continuing through until the patient is fitted with a prosthesis.

Prescription of and fitting an adequate prosthesis is a highly variable problem. For the last ten months the Rehabilitation Institute of Chicago has conducted an Amputee Clinic wherein the amputation consultant, the referring physician and/or agency, representatives of the limb manufacturers, staff members of the Rehabilitation Institute, including physical therapists, occupational therapists, medical social worker and medical director, have all participated in evaluating the clinical, social, vocational and economic problems of the amputee. Vocational counselors and vocational placement, as well as personnel representatives, have also participated. By this means, we have been able to determine a number of factors concerning the ultimate welfare of the amputee and have been able to resolve difficulties which have previously been considered major stumbling blocks in the way of proper solution of the problem. The value of such a clinic is greater than the sum of those who attend; i.e., the patient may have been "sold" on a given type of prosthetic device which will not meet his requirements. At the amputee clinic it is a simple matter to discuss his total problem and give the patient better perspec-

tive as to his best interests. Prosthetists, social workers, vocational counselors and the patient are all encouraged to express their opinions. It is becoming increasingly evident that a team effort of this sort is worth the time and expense involved. (The Veterans' Administration, in cooperation with the National Research Council, has demonstrated similar results in their amputation clinics.)

Regardless of whether the patient is seen at an amputation clinic, as described above, or in the physician's private office, there are several considerations which must be borne in mind in prescribing an adequate prosthesis:

1. *Has the patient accepted his amputation?* We tend to make an *apriori* assumption that anyone who has suffered a major amputation will want to have and to use a prosthesis. However, such is not the case. There are numerous reasons why any given patient may not accept his amputation, ranging all the way from religious superstition to ill advised economic retaliation. The clinical signs indicating lack of acceptance are not well delineated, but may include such behavior as complaint of pain beyond all physical reason, general lassitude or disinterest on the part of the patient, repeated failure to keep appointments and, finally, constant bickering between the patient, the prosthetist and the physician, wherein the patient skillfully plays the physician against the prosthteist and the prosthetist against the physician. We have enumerated only a few of the signs of lack of acceptance and this lack of acceptance may go on for many years or, in favorable situations, may be overcome by a gradual process of more adequate understanding of the patient's total personality.

2. *In prescription of the prosthesis, consideration of the over-all usefulness of the prosthetic appliance:* We recognize the relative limitations inherent in shoulder and hip disarticulation prostheses from a functional point of view. It is exceedingly important that the patient who has had a major disarticulation be assisted to realize the functional limitations inherent in the prosthesis, however adequate it may be from a cosmetic point of view.

3. In upper extremity amputations it is of course easier to obtain the full cooperation of the bilateral upper extremity amputee than of the unilateral amputee. Other things being equal, the below-elbow amputee will perform more adequately than the above-elbow amputee. However, by all odds in the upper extremity amputation the most important consideration is the terminal device, or devices, to be prescribed. We are all aware of the fact that the prosthetic hook, whether it be the APRL, Northrop 2-load, or the Dorrance, is likely to be more useful from a vocational point of view than are the prosthetic hands currently available. Time does not permit of detailed discussion of the various merits of the several terminal devices which may be used. Generally speaking, it may be said that the terminal device initially prescribed should be one that will meet the heaviest work-load demand of the wearer. The same general statement also applies to the matter of the shoulder harness and the control cables. Too delicate a terminal device is just as discouraging as too heavy a terminal device. The only way to determine the maximal work-load which the patient may undertake is to explore in detail the type of vocational pursuit which is anticipated in the immediate future.

When a differentiation must be made between the cosmetic and the functional value of the terminal device, it has been our experience that the functional factor should receive major consideration. When the patient has become adept in using the functional terminal device, he can easily switch to a cosmetic hand and still maintain a higher percentage of functional capacity for social as well as vocational purposes.

4. Lower extremity amputees also present problems in regard to proper prescriptions and fitting of the prosthesis. The understandable enthusiasm for suction-socket prostheses for the above-the-knee amputees has generated a great deal of interest on the part of the medical and lay groups. It has been our experience that younger amputees, those under forty, have a better chance of successful use of the suction socket. It must be emphasized, however, that age alone is not the sole deciding factor. The status of the remaining extremity, the patient's general physical condition, the length of time since the amputation and, of course, the stump itself, must all be taken into account before determining the advisability, or otherwise, of a suction-socket type of prosthesis. Similar problems present themselves in regard to below-the-knee amputees, where, in the presence of a short stump, the question of a slip socket may be raised.

Before considering the re-employment potential of the amputee, let us say a few words regarding training: When the amputee first receives his prosthesis, he is awkward in its use and feels that he has an additional burden. A period of intensive training under the guidance of the physician and qualified physical and occupational therapists assists the patient in the acceptance of the prosthesis and to become skillful in its use. Limb manufacturers do not have time or personnel sufficient to provide this training. It is worse than futile to spend several hundred dollars for a prosthesis, only to have it end up in the closet.

TABLE I

REHABILITATION INSTITUTE OF CHICAGO—AMPUTEES—MARCH 1, 1954 TO OCTOBER 18, 1954

1. Patients in training	11
2. Patients finished training and working, or in school	24
3. Patients finished training and still unemployed	9
4. Patients finished training but considered unemployable	1
5. Patients waiting for prosthesis	20
6. Patients not feasible for prosthesis	9
7. Deceased	2
	76

We will assume that an adequate prosthesis has been supplied and the amputee has been given proper training in its use. The major barrier to re-employment in the group of amputees that have been seen by us at the amputation clinic as part of the Rehabilitation Institute has been age. It has been pretty well shown that a so-called normal person over forty-five years of age has odds of six to one against getting a job, as compared with the so-called normal of the younger age group. It would be surprising, therefore, if age plus an amputation were not the major barrier to re-employment. Since March 1, 1954 (Table I and Table II) some seventy-six major amputees have been seen in our amputation clinic; of these, sixty-two were male and fourteen were female. Of the sixty-two males in this group, forty-one are forty-five years of age or older; and of the fourteen females, seven are forty-five years of age or older. Not all of these patients are new amputees but a high percentage are receiving their first prosthesis. Of the total group of seventy-six the following figures are also of interest: As of October, 1954, there were eleven in training, learning to use their prosthesis. Twenty-four of the seventy-six had completed training and are back at work or are in school. Ten have completed training and are unemployed or are considered unemployable. Of this latter group of ten, only one fits into the unemployable category. Twenty of the seventy-six are waiting for the delivery of their prosthesis while nine of the total group of seventy-six were considered non-feasible for a prosthesis. Finally, two of this group of seventy-six have died since March 1st. One of the deceased patients was in the group considered not feasible for a prosthesis because of a bizarre circulatory picture including advanced cardiac disease in a forty-three year old man. The other deceased patient was fitted with a prosthesis, returned to work of a part-time nature and expired suddenly as a result of an embolic episode somewhat similar to the one which had caused this patient to lose his leg some five years ago. This latter patient was over sixty-five. One other observation in regard to this group of seventy-six patients may be worthy of note, namely, forty-three of the patients had amputations due to disease (including congenital absence of arm or leg); thirty-three of this group had amputations because of trauma. Of particular interest to this Association, from the experience on which we are reporting, it may be said that the most favorable prognosis from the standpoint of re-employment potential occurs when the patient has lost an arm or a leg as a result of accident. Let us take a case history, for example:

TABLE II

REHABILITATION INSTITUTE OF CHICAGO—AMPUTEES—MARCH 1, 1954 TO OCTOBER 18, 1954*

Age (yr.)	Male	Female
5–14	1	..
15–24	3	1
25–34	5	1
35–44	11	5
45–54	12	2
55–64	23	5
65–over	7	..
	62	14

* Amputations due to trauma, 33; amputations due to disease, 43; total, 76.

Mr. P., a twenty-four year old factory worker, on the job with the same industrial organization for eight years, suffered a crushing injury to the left arm on December 31, 1953, resulting in a below-elbow amputation. At the time of the injury, Mr. P. was making $60 a week.

Following surgical repair, the patient was referred by the industrial physician to the Rehabilitation Institute of Chicago, on February 4, 1954. Upon examination it was determined that the stump was not yet ready for prosthesis because of swelling and tenderness. Mr. P. was started on physical therapy which included whirlpool bath, massage, active exercise and bandaging to toughen and shrink the stump.

In the amputation clinic session on February 24, 1954, a suitable prosthesis was prescribed by the (amputation) consultant. On March 17th the below-elbow appliance was delivered to the Institute and the patient was given intensive training. He became quite skillful in the use of his artificial left arm and was discharged from the Institute on April 5th. On April 26th he returned to work.

On follow-up two months later, it was learned from his employers that "We are very pleased with Mr. P.'s adjustment. He is a better and more conscientious worker now." At the present the patient is working as a production record supervisor at a salary of $75 a week. His chances for advancement in his present job, the company states, are greater now than before the injury.

The cost of Mr. P.'s rehabilitation, including his prosthetic arm, was less than $500 00.

It should be pointed out that this particular individual, had he been left to the interests of the compensation insurance carrier or to the routine practice of the personnel manager of the plant, would probably have not been re-employed. This serves to emphasize the importance of the personal element in the reemployment potential of any amputee: A person who is informed of the abilities of the amputee is in a position to provide valuable information to the prospective employer, at which time it may be clearly shown that the amputee has more ability then disability. It was this type of approach which proved successful in obtaining re-employment for the patient we have just considered.

Another aspect of the re-employment potential of the amputee has to do with workmen's compensation laws in the various states. Unfortunately there is no uniformity of compensation statutes, so that each state has its own peculiar situation with which to contend. In the State of Illinois, for example, the second injury clause is not applicable when an individual has lost an arm or leg due to a disease or injury which is not compensable. Also, it is our understanding that the signing of a waiver on the part of the would-be employee is useless. Thus in the case of the amputee, whose amputation was a non-compensable injury, any employer who puts him on the job potentially subjects himself to total disability compensation should the employee become disabled as a result of aggravation of pre-existing condition or additional trauma. It is obvious that in such a situation the re-employment potential of any given amputee is considerably reduced. Management and labor must meet this problem realistically and join forces to assure the proper placement and honest management of any difficulties which may ensue at a later date during the course of such a patient's employment. For example, one of our amputees is a man of fifty-six who sustained an above knee amputation due to arteriosclerotic disease. He was fitted with a prosthesis, trained in its use and is able to travel and do anything necessary for daily living. His employment record has been excellent—twenty years with one large firm. The medical director and the chief of personnel of this particular firm have talked with us concerning the problem of re-employing this particular person; the medical department has cleared him for employment from a physical point of view. However, it has been stated that should this man receive a minor injury to his good foot, which could quite possibly lead to gangrene and result in amputation of the remaining leg, this firm would be considered totally liable under the statutes of the State of Illinois; and even though the individual employee himself might not bring suit, the union steward, in his particular portion of the plant, would insist that he bring suit inasmuch as it is pretty clear that some of the union stewards and some members of the legal profession are in "cahoots" to the extent that any settlement that is obtained will be split, not just between the lawyer and the client, but apparently a three-way split—the lawyer, the client and the union steward. In fact, there are on record several cases of employees who were the victims of goon squad methods because they failed to agree to suing the firm for "total disability compensation."

It has been our experience to date that the

best employment potential for amputees usually may be found in small industry and small business. The reasons for this are: First, that in the small concern each individual is seen as a person and their abilities are used on a more personalized basis than is possible in the larger or highly organized industry or business. Second, small business or industry is not as stratified as far as seniority privileges or different union or craft practices are concerned. Therefore, there is a greater latitude within which personnel may be shifted in order to accommodate the altered capacity of the amputee and permit him to perform his most useful functions. Third, from a purely economic standpoint, a suit against a small industry or business is not likely to be productive of a real settlement to the extent of several hundred thousand dollars as compared with the greater resources inherent in larger industry. Neither the second nor third point outlined above is a valid reason for looking to small industry for re-employment of the amputee, however, they are exceedingly practical reasons at our present state of development.

A few words as to the types of employment now being followed by the twenty-four amputees who are back on the job or in school. Three are students, three are housewives, and the rest of the employed group are engaged in the following types of jobs: Janitor—handyman; radio assembly worker; drug store clerk; taxi dispatcher; hotel clerk; office worker (three); machine operator; cook's helper; small business man; banker; laborer; stock room clerk; body-fender repair; school maintenance man; bakery worker; restaurant counter man and welder.

What, then, are the re-employment potentials of amputees? *Age, associated systemic disease, employment record, academic achievement* and last, but not least, *motivation* of the individual patient are all important considerations in trying to assay the re-employment potential. Over the past twenty years it has not been possible for us to observe any general rule which will apply to all amputees. There are perhaps 5 or 10 per cent of people who, regardless of disease or injury, will return to productive status in spite of, as well as because of, any help the medical profession may be able to provide. At the other end of a normal distribution curve, there are another 5 or 10 per cent of people who, regardless of the most intensive rehabilitation effort, will successfully resist all opportunities to become productive citizens and continue to enjoy an allergy which is apparently inborn. This is an incurable allergy to that little word known as "work." The real challenge to all of us in the medical profession lies in the 80 to 90 per cent of persons who fall in the mean portion of the normal curve, wherein it can be stated that, other things being equal, the earlier rehabilitation measures are begun, the more adequate and intensive they are, and the more purposeful they can be, results in a speedier recovery, a more adequate recovery and a higher level of productivity on the part of the restored individual. Quite obviously, it is easier to place amputees at a time when the labor market is in short supply, as is true during periods of major conflict. However, the placement of any given individual is a highly personalized undertaking and, even in a tight labor market, it is not too difficult to assist in the successful reemployment of the amputee if his abilities are such as to outweigh his disability.

In conclusion, we have attempted to delineate a few of the factors influencing the re-employment potential, as well as some of the problems in the rehabilitation of amputees. The various movements to employ the handicapped and emphasis on selective job placement are all helpful. Our primary attention, however, should be directed at the *abilities* of the individual rather than his disability; it is well to remember that no one has ever placed an upper or lower extremity prosthesis on a payroll. The only way in which a prosthesis can get on a payroll is through the person who is using that prosthesis to be a productive and happy worker.

DISCUSSION OF PAPERS BY DRS. THORNDIKE AND BOYNTON

JOSEPH R. SHAEFFER (Washington, D. C.): I am flattered in being referred to as an expert in this field and also regret that I did not hear the entire paper.

The problem in the military is one presenting many difficulties. We still have a fair percentage of individuals from the Korean incident who are in need of rehabilitation. We have by law passed the major part of this responsibility directly to the Veterans Administration. One of the problems that we are faced with professionally, particularly where we have transient doctors with variable training

and experience, is to get them to transfer all amputees early to a veterans' facility which is better staffed than we are to follow through and complete the patients' treatment and rehabilitation.

On the other hand, we do not like to divorce our thinking from the over-all responsibility, and are extremely sympathetic with the individual doctor's point of view that he should maintain contact with his patients from start to finish. One of the undesirable parts of our training program would seem to be that some of these patients with long-term programs must be transferred from our supervision over to another group of doctors.

We overlook some of these and try, insofar as we can for educational and training purposes, to encourage that much of the definitive care be carried out by the individual doctor before they are transferred. We then attempt a follow-up of these cases by direct correspondence with the patients themselves.

The problem, we recognize, is an important one and increases with each incidence of war. Our percentage of amputees from the Korean incident has been reduced considerably with the more recent advances that we have had in vascular surgery. Arterial repair has saved us a tremendous amount of rehabilitative work and certainly has saved the Government hundreds of thousands of dollars, which would be necessary for adaptation and rehabilitation of these individuals.

NORMAN L. HIGINBOTHAM (New York, N. Y.): I have listened to Dr. Thorndike's and Dr. Boynton's papers with considerable interest. I do want to stress one point that neither of them had an opportunity to bring up, which I am sure they will agree with, namely, that the problem of rehabilitation begins with your first contact with the patient. So often those of us who have to perform many amputations go ahead with the indications for the amputation, perform the operation, take care of the patient in the hospital, discharge him and then leave him on his own; or at a later date, we send him to an amputee clinic, rehabilitation clinic and expect the latter to take up three or six months later to correct the deficiencies that we have left in that gap.

Of course, when a traumatic amputation occurs, and the amputation is an emergency, one does not have much time to prepare the field. On the other hand, Dr. Coley and I, at our clinic at Memorial Hospital in New York, have an opportunity to prepare the way.

When we have a patient with a malignant tumor and an amputation is definitely indicated, we believe that that is the time to begin our program of rehabilitation and even re-employment. The patient has to be approached with the problem. He has to be sold on the idea of the necessity of the amputation, and that is a good time to acquaint him with the possibilities of his future life minus his limb.

Patients are taught early that it is not what they lost or will lose that matters; it is what they have left that they have to work with, and which will make them the rugged individual that we expect them to be.

To this end, we have had the advantage of forming an Amputees Alliance. The original nucleus was drawn up five or six years ago. We got together some of our amputees of upper arm and lower extremity, and we formed the nucleus of a group of amputees that became incorporated and is known as the Amputees Alliance.

There are now fifty-eight active members in this association. They meet once a month and they have an annual dinner. They hold it at the Waldorf-Astoria, in New York. At the last dinner thirty-eight of the amputees showed up with their friends and relatives, making a total of 200 people attending this dinner. It was reassuring to us, as well as others of the profession that were there, to see some of these amputees with high amputations—ours are all high since they are for malignant tumors—get up on the dance floor and dance around. I have seen a patient with an interscapular-thoracic amputation and a patient who had hip joint disarticulation dancing with no feeling of embarrassment because they knew they were among friends. It is really surprising, when the way has adequately been prepared, what some of these patients can do.

We have thirty-two hemipelvectomies, twelve of whom are wearing artificial limbs. When we did our first hemipelvectomy seven years ago, neither of us could ever believe that a prosthesis could be fitted to a case such as that, but we now have twelve of them. Of interest is one of these patients who is a worker in a doughnut factory. That was his job before his amputation. Six months after his hemipelvectomy he received his prosthesis. Three months later he was back at work in the doughnut factory. His job, incidentally, is pulling the long trays of doughnuts out of the oven with a poker or hook and when that tray is unloaded, he pushes the tray with its new load back in the oven again. He does that job not eight hours a day but works six hours a day regularly at his job, and has lost very little time from his work.

Motivation has been mentioned by Dr. Boynton and Dr. Thorndike. I would like to stress it, because it is the motivation of the patient that makes the difference in his rehabilitation and in his re-employment.

A recent interscapular-thoracic amputation that we did at Memorial for an osteogenic sarcoma of the upper end of the humerus was on a professional golfer, thirty-eight years of age. After the amputation he was sent home to West Virginia to recuper-

ate with facilities for his care down there. He returned to see us in our clinic in New York, and said, "Do you know where I have been this morning?" I said, "No, I'd be interested to find out, though." He said, "I have been out on the golf course. I went around in 81." I said, "Isn't that nice, nine holes in 81." He answered, "Eighteen holes."

He was going to make a film for television purposes to demonstrate to other shoulder and interscapular-thoracic amputees how a professional golfer could play golf with one arm.

Motivation is a big factor, and I think everything we can do, even if we can form an Amputees Alliance to get these folks together or use other means to boost their morale and give them that motivation, would be worth every effort we can put into it.

ROBERT MAZET, JR. (Los Angeles, Calif.): Dr. Thorndike's report is of particular interest to me, perhaps, because I have followed this rather closely, and I would like to say a few things to supplement what he said.

The suction socket program, as he pointed out, cannot be regarded as a completed program. It is not a static program. The work is not finished, by any means. I am sure you all know that the group at the University of California at Berkeley, with the facilities of the Naval Hospital at their disposal, are continuing the work of this program.

One of the things they have developed, which I believe is becoming more generally used, is the alignment jig. This is very helpful in lining up these prosthetic devices.

Under Dr. Thorndike's direction, and that of the Advisory Committee on artificial limbs, some other things will come out of that program before too long.

The below-knee suction socket has been gone into rather thoroughly. Various types of new knees and feet are being investigated. The new prosthesis for hip disarticulation, developed by the Canadians, is now going through closer scrutiny and field testing.

Our ideas have changed a little with regard to some things about suction socket. For instance, in the beginning everyone thought that these could not be fitted tightly at the top because this would interfere with venous return. This was very carefully watched. Actually, there has been some change in feeling about this. I now think these sockets are considerably tighter at the top since it has been demonstrated that the congestion and interference with return occurs more frequently from choking at the bottom than from the top.

Another thing which has surprised us a little is that the anticipated increase in diameter from muscular hypertrophy, which was mentioned, has not been as great as we thought it would be. Probably this is due in part to the fact that the fatty tissue, which these people develop, is replaced by good muscle, so that actually the amount of muscle probably increases but the circumference of the leg does not increase too much as a rule.

One of the things Dr. Thorndike mentioned as a complication of suction socket wearing was that these people sometime develop furunculosis and cysts at the top of the socket. This is true, but I do not think it is any more common with such a socket than it is with the conventional type of prosthesis. We all see it. I doubt very much if it is too important.

Dr. Higinbotham took the words out of my mouth with regard to the team approach which everyone has emphasized and which we think is very important. I would like to say again that I agree with him entirely that the surgeon's responsibility to the patient does not end with removal of the extremity. It must carry on through the rehabilitation program and indefinitely.

AUGUSTUS THORNDIKE (Boston, Mass.): Dr. Higinbotham has emphasized group therapy in this alliance of amputees. It is through group therapy that the amputee is reached and his motivation stimulated. There are good cases and bad cases in the room together, contrary-minded and cooperative patients, and one can change an attitude very quickly by bringing such types together. The competitive spirit should be built up in the rehabilitation program among the patients. Then the will to get well and to do better would naturally be developed.

BEN BOYNTON (closing): The paper as read is considerably abbreviated from the paper as written, and perhaps more material would bear out what Dr. Higinbotham mentioned, namely, that rehabilitation begins at the time medical care starts. That, I think, cannot be stressed too strongly. It is true not only of amputees; it is true, I think, of most any difficulty that is likely to lead to a serious disability.

The fact that motivation is important I am glad was stressed again. The importance of motivation in the amputee cannot be overemphasized, and again let me reiterate what Dr. Thorndike has just mentioned, namely, getting the patients together, competing with each other, is one of the most successful means of motivation with which I am acquainted.

I was pleased Dr. Higinbotham mentioned the professional golfer, who, after being seen on checkup, was on his way to see a couple of other ampu-

tees to show them how he could use his prosthesis. This again, is the very best way of helping amputees that I know of to motivate them to do the most with what they have.

I think we tend to take too dim a view of the prosthesis for major joint disarticulation. Dr. Stack has a patient upon whom he has performed a hemipelvectomy. This patient is now working, so far as I know, with his prosthesis. He, too, is a golfer; however, he was not as good as Dr. Higinbotham's patient, as far as score was concerned.

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Buffalo, New York

From the Surgical and Orthopedic Services of the Meyer Memorial Hospital, University of Buffalo School of Medicine, Buffalo, N. Y.

IN Buffalo six hospitals have Trauma Conferences which were organized under the influences of the Regional Committee on Trauma of the American College of Surgeons.[1] This presentation deals solely with the Meyer Memorial Hospital which has the only Trauma Conferences in Buffalo which involves undergraduate students. The conferences are weekly ninety-minute sessions attended by visiting surgeons, resident surgeons, interns and medical students of the junior and senior years. The average attendance is thirty-five, about half undergraduates. Many of the surgeons who attend the conference regularly are general surgeons, but frequently there are more orthopedists present than general surgeons. The scope of interest of the conference is broad, including the problems of burns, hemorrhage and thoracic and abdominal injuries. Neurosurgeons, urologists, thoracic surgeons and other surgical specialists are occasionally invited to participate, when problems of interest to them are presented.

At the Meyer Memorial Hospital, fracture cases are admitted to the general surgery service on the odd months and to the orthopedic service on the even months. Cases admitted to a service continue on that service for treatment, unless the service negotiates a transfer. After discharge orthopedic fracture cases are referred for follow-up to the Orthopedic Clinic; fractures from the surgical service are referred for follow-up to the General Surgery Fracture Clinic. All cases are service cases unless bonafide arrangements for private care have been made by the patient's physician, or unless the patient asks for a specific staff member on a pay basis.

The general surgical resident in admissions acts as a screening and admitting officer for fractures. After evaluating the case, he calls the surgical or orthopedic attending on duty, according to the month. If the patient has multiple injuries, or serious associated disease as well as a fracture, the general surgery resident on duty decides which is the lesion most urgently requiring treatment and admits the patient to the proper service. In each such instance, however, he calls the general surgery or orthopedic attending on duty and reports the case. In other words, it is the duty of the surgical resident in the admissions department to see that the patient gets proper care by the proper service without delay.

The teaching resident on the general surgery service arranges the schedule of four to six cases for each conference in advance, drawing cases from any service. Last minute changes in the program are frequently made in order to present fresh cases. Recently an outpatient with a subcoracoid dislocation of the shoulder was brought into the conference room with the wet x-ray films. Following discussion, one of the surgeons undertook to demonstrate the ease of reduction without anesthesia by the Kocher maneuver. The attempts were unsuccessful. The demonstration was especially valuable education; it was a session which none can forget.

The conference is presided over by a senior clinician with the aid of the teaching resident. Brief case reports are presented by someone prepared to give the salient facts and also to answer questions about the case. The report is usually given in two to five minutes by the assigned medical student, but may be given

by a member of the house staff or one of the visiting surgeons. All are encouraged to bring their problem cases to the conference for free group consultation. The history of the case is given up to but not including definitive treatment, in order that discussion may be without prejudice. The x-ray films are displayed and all present are encouraged to gather around the view box for a few minutes. Then the discussants are heard, usually in inverse order of seniority, in order that there may be no constraint to agree with the views previously expressed. Patients are sometimes demonstrated briefly and opportunity is offered for brief examinations.

Differences of opinion are, of course, frequent and at times acrimonious. The participants all understand that the clashes are in a spirit of good sportsmanship and that there would be no point in having such a conference if we were to agree politely on all questions of the surgery of trauma. The undergraduates enter into the spirit of the sessions with apparent enjoyment, and frequently take sides in the discussion. We believe that the best teaching conferences may well be the most unruly ones.

Such sessions stimulate critical thinking and investigation on the part of all participants, students, interns, residents and visiting surgeons. Benefit to the patient in improved care is frequently obvious. However, the responsibility for patient care rests on the service concerned and not on the Trauma Conference.

At this point in the program a Trauma Conference drama was presented. The stage was quickly set as a classroom. Dr. Brown presided with the help of Dr. Schenk who impersonated the teaching resident. Dr. Potter acted the part of an unusually stupid third year medical student. The other actors represented themselves in their customary roles in the weekly Trauma Conferences: Dr. Cole, orthopedist; Dr. Dziob, general surgeon; Dr. Hale, general surgeon; Dr. Stiff, radiologist. Cases were discussed freely and informally, with some vociferous expressions of differences of opinion.

CONCLUSION

Trauma Conferences provide a forum for the free exchange of ideas pertinent to specific cases among general surgeons, orthopedists and others concerned with the care of the injured.

Trauma Conferences promote better care of trauma cases in their initial, reparative and restorative phases, placing emphasis on the broader aspects of trauma as well as on musculoskeletal injury.

Trauma Conferences can provide practical and theoretic instruction at various levels of surgical education and serve as a basis for either a consolidated trauma service or a division of trauma cases between general and orthopedic surgery without loss of teaching value of the material to any one service.

REFERENCE

1. Dobbie, R. P. Are we fulfilling our responsibility to the injured? Buffalo General Hospital Trauma Conference. *Bull. Am. Coll. Surgeons*, March, 1952.

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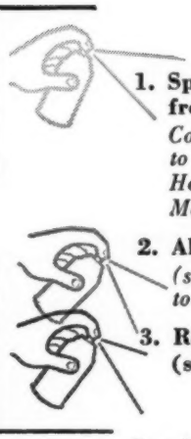

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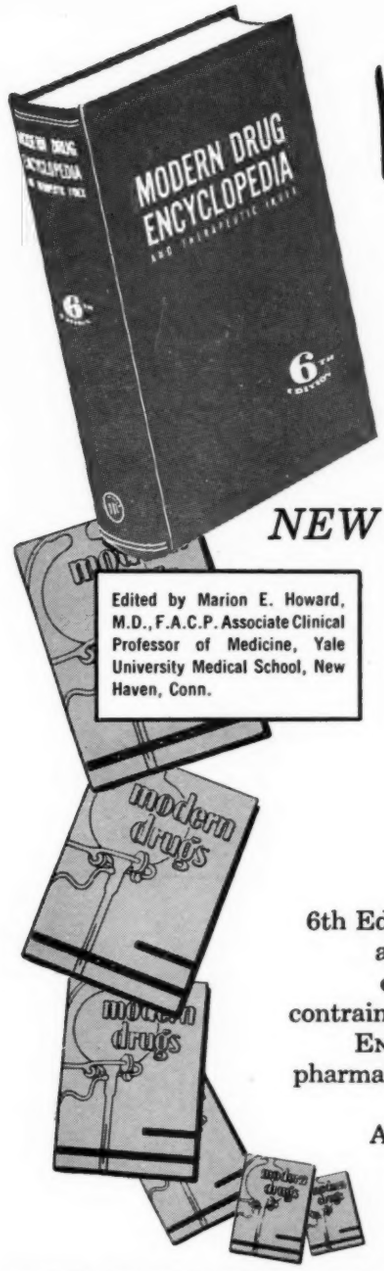

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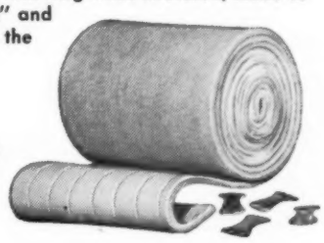

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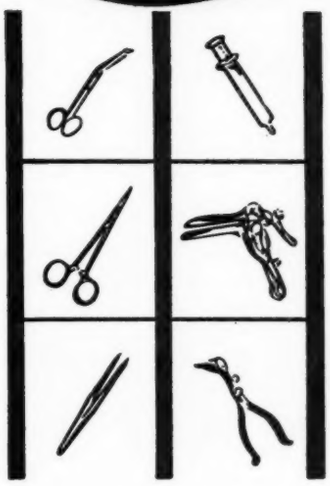

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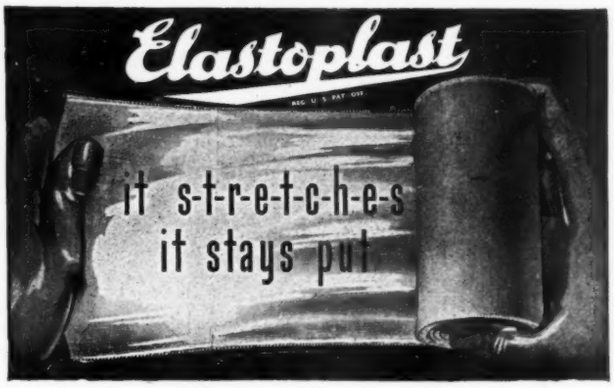

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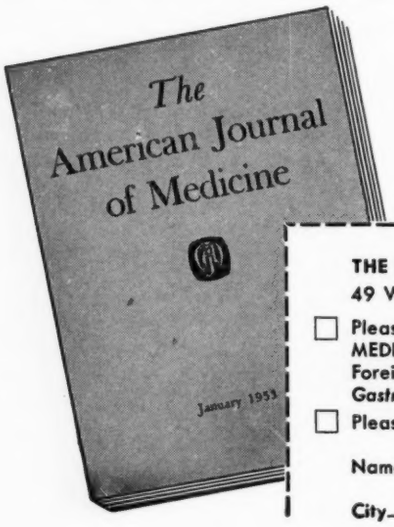

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General Surgery, Two Weeks, April 25; One Week, May 23
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Thoracic Surgery, One Week, June 6
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An Announcement

The outstanding Symposium on BRONCHOPULMONARY DISEASES will be continued to completion in a special department in the following issues of The American Journal of Surgery—May, June, July, October and December.

The enthusiastic reception of the first section of the Symposium published in the January issue indicates an unusual interest in diseases of the lung.

Included in forthcoming issues are the following articles and authors:

Diagnosis and Treatment of Pulmonary Tuberculosis
Roger S. Mitchell, Trudeau, N. Y.

Current Status of Antimicrobial Agents in the Treatment of Pulmonary Tuberculosis
Nicholas D. D'Esopo, West Haven, Conn.

Pathology of Tuberculosis as Affected by Antibiotics
Oscar Auerbach, East Orange, N. J.

Mechanisms of Fatal Pulmonary Hemorrhage in Tuberculosis
J. Robert Thompson, Chicago, Ill.

Indications for Treatment of Tuberculosis in Children
Edith M. Lincoln, New York, N. Y.

The Role of Resection for Pulmonary Tuberculosis in Children and Adolescents
Morris Rubin, New York, N. Y.

Surgical Treatment of Pulmonary Tuberculosis
Norman J. Wilson, Orlando Armada, William B. O'Brien and William V. Vindzberg, Brookline, Mass.

Segmental Resection for Pulmonary Tuberculosis
J. Maxwell Chamberlain, New York, N. Y.

Home Management of Pulmonary Tuberculosis and Other Forms
Donald R. McKay, Buffalo, N. Y.

Present Status of Pneumotherapy in the Management of Pulmonary Tuberculosis
James H. Cullen, Albany, N. Y.

Management of Bronchiectasis in the Older Patient
Helen Sinclair Pittman, Boston, Mass.

Bronchiectasis
Francis M. Woods, Brookline, Mass.

Acute Lung Abscess
S. Aubrey Gittens and John P. Mihaly, New York, N. Y.

Lung Abscess—A Medico-Surgical Problem
David H. Waterman, Sheldon E. Domm and William K. Rogers, Knoxville, Tenn.

Airspace Abnormalities of the Lungs
Israel Rappaport and Edgar Mayer, New York, N. Y.

Roentgen Manifestations of Pulmonary Tension Disorders in Infants and Children
John A. Campbell, Indianapolis, Ind.

Cystic Disease of the Lung with Emphasis on Emphysematous Blebs and Bullae
Jerome R. Head, Chicago, Ill.

Pulmonary Air Cysts
David J. Dugan and Kenneth L. Hardy, Oakland, Calif.

Infected Cystic Disease of the Lung
Richard H. Meade, Grand Rapids, Mich.

Intralobar Bronchopulmonary Sequestrations
Andre J. Bruwer, Rochester, Minn.

Hydatid Cysts of the Lung
Louis R. Davidson, New York, N. Y.

Pulmonary Manifestations of Systemic Diseases
Eli H. Rubin, New York, N. Y.

Pulmonary Roentgenologic Changes in the Collagen Diseases
L. Henry Garland and M. A. Sisson San Francisco, Calif.

Generalized Amyloidosis
Irving J. Selikoff, Paterson, N. J.

Mycotic Infections of the Bronchial-Pulmonary Tract
Arthur Q. Penta, Schenectady, N. Y.

Pulmonary Histoplasmosis
Thomas F. Puckett, Denver, Colo.

Surgical Considerations in Pulmonary Coccidioidomycosis
Bert H. Cotton and J. W. Birsner, Los Angeles, Calif.

Silicosis and Asbestosis
O. A. Sander, Milwaukee, Wisc.

Beryllium Poisoning (Beryllosis)
H. E. Tebrock, New York, N. Y.

Pneumoconioses—Pathogenesis and Management
Arthur J. Vorwald, Detroit, Mich.

Foreign Bodies in the Bronchopulmonary Tract
Walter H. Maloney, Philadelphia, Pa.

Penetrating Wounds of the Lung
Aubre de L. Maynard, New York, N. Y.

Extrapleural Pulmonary Resection
Irving Sarot, New York, N. Y.

Present Concepts Relative to Autonomic Nerve Surgery in the Treatment of Pulmonary Disease
Osler A. Abbott, Emory University, Ga.

Thrombosis of Pulmonary Arteries
D. R. Keating, Cleveland, Ohio

Pulmonary Embolism and Infarction
Irving S. Wright and William T. Foley, New York, N. Y.

Fundamental Considerations in the Chemotherapy of Acute Pneumonias
Paul Bunn, Syracuse, N. Y.

Allergic Manifestations in the Respiratory Tract and Treatment
Joseph Harkavy, New York, N. Y.

Use of Corticotropin and Corticosteroids in Pulmonary Disease
M. S. Segal, J. A. Herschfus and A. Salomon, Boston, Mass.

Use of Exsufflation with Negative Pressure in Postoperative Patients
Edward K. Williams and Duncan A. Holaday, New York, N. Y.

Indications for Tracheotomy Following Thoracic Injuries or Operations
Mark H. Williams, Binghamton, N. Y.

Management of Impaired Respiratory Function
James L. Whittenberger, Boston, Mass.

Effect of Pulmonary Disease in Inhalation Anesthesia
Joseph Giuffrida and Dante Buzzari, Brooklyn, N. Y.

Importance of Rehabilitation in Thoracic Surgery
Albert Haas and Howard A. Rusk, New York, N. Y.

Selection and Management of Patients with Thoracic Diseases for Air Travel
Burgess L. Gordon, Philadelphia, Pa.

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NOTES AND QUOTES

An estimated 60,000 physician-visits will be paid to closed-circuit color television programs at fifteen postgraduate medical meetings in 1955, Smith, Kline & French Laboratories announced in releasing the schedule for its sixth consecutive year of medical color telecasting.

In June, 1949, physicians attending the Annual Meeting of the American Medical Association saw color TV's first public performance. Since that time, Smith, Kline & French has presented color telecasts for sixty-five medical meetings in this country, Canada and abroad. More than 327,000 doctor-visits have been paid to the SKF programs thus far, one indication of the popularity of the closed-circuit medium among members of the medical profession.

To carry out such an extensive schedule, SKF has developed a ten-man color television unit which devotes its entire time to the production of the telecasts and the maintenance of some 18,000 pounds of television equipment. The unit is unique in the television industry in that it is the only completely mobile television station in existence.

Smith, Kline & French also produces and sponsors the award-winning "March of Medicine" series in cooperation with the A. M. A. on the NBC network. In addition, on February 9th, SKF telecasted "Videclinic" to an estimated 18,000 doctors in thirty-one cities, comprising the largest single medical audience ever to witness a closed-circuit television program. "Videclinic" was presented by the A. M. A. and the local and state medical societies as a means of bringing a great number of physicians up to date on the latest advances in medicine.

Silicone-coated blood bottles, valuable in prolonging the life of an important blood component, are now commercially available for the first time, it was announced by Baxter Laboratories, Inc., of Morton Grove, Ill.

The invisible silicone on the inside of the bottle prevents blood platelets from coming in contact with the glass. Platelets are vital in the control of hemorrhage and most investigators believe that platelet life span is increased by preventing contact with glass.

Platelets serve two functions in stopping certain types of hemorrhage. They initiate blood coagulation by breaking down and liberating an enzyme which helps the blood to clot, and they plug the opening of tiny bleeding vessels.

Intact platelet transfusions are used to treat certain blood clotting disorders in which the patient has a low platelet count and prolonged bleeding time. Research has indicated that platelets are kept intact and effective for longer periods when the blood for transfusion is drawn into silicone-coated bottles.

The John A. Hartford Foundation has awarded Yale University a grant of $3,160,000 for research and training in biophysics and the construction of a new research laboratory.

Yale will receive this total sum in the form of an annual grant of $180,000 for the next fifteen years, plus $460,000 for construction of the new laboratory.

The new 10,000 square foot biophysics research laboratory will be located on the Hartford Foundation's property in Valhalla, N. Y. The instructional phase of the biophysics program will be centered in New Haven, while research activities will be conducted both at Yale and at Valhalla.

A Duke research team comprising Drs. Beard, D. Gordon Sharp, Edward A. Eckert and Dorothy Beard for the first time has purified a true cancer virus which causes erythromyeoblastic leukosis, a disease closely resembling human leukemia.

The Duke team isolated and concentrated the virus almost four years ago, but now they have definitely purified it. The research tool for establishing purity of the virus preparations is an immune serum, artificially produced in chickens, which neutralizes the virus.

The researchers also have "proved conclusively" that this virus has enzyme activity which undoubtedly plays a major part in producing cancer.

They have proved further that the virus contains tissue which is indistinguishable from the normal tissue of the invaded cell.

These discoveries greatly broaden the knowledge of the nature of viruses and probably will reopen investigation of other viruses believed to have enzyme activity.

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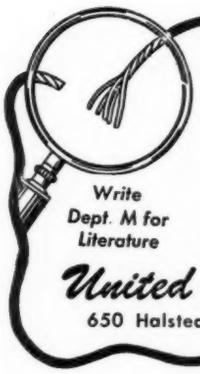

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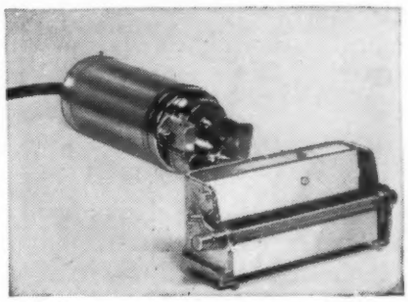

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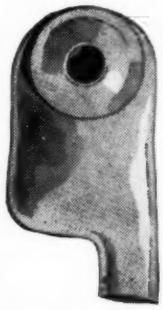

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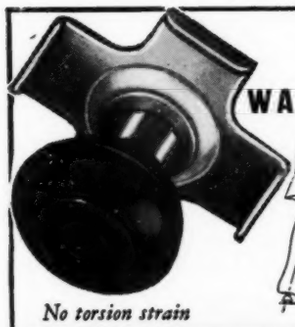

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NOTES AND QUOTES

Proof of subjection to sterilization of packs, bags, trays and tubes is now available as a result of improvements in Johnson & Johnson's Tyloc pressure-sensitive tape. This new tape changes color from bright yellow to buff after sterilization, whether by dry or steam heat. The change in color after sterilization does not affect ink, ball point pen, pencil or other labeling imprints. The bright yellow background is excellent for labeling purposes. Quick-stick and shelf life also have been improved in the new formula.

The improved Tyloc tape is now available at all Johnson & Johnson shipping points. The original tape, without color change, has found wide acceptance in the hospital field since its introduction in 1953. It has replaced pinning, tying and tucking technics. The new color change feature has been incorporated at no increase in price.

CONSTRUCTION of Wyeth Laboratories new multimillion dollar headquarters building and research laboratories in Radnor Township, twelve miles west of Philadelphia, is going on at a fast pace. To acquaint those employees who will move to the building in mid-1955 with the progress of their new home, the company recently took 700 of their people on a "go and see" tour of the construction.

Scientists who require specially designed laboratory apparatus may now select custom-made items from a new catalog published by Corning Glass Works. More than 2,600 pieces of special apparatus, many of which have never before been listed formally, are included in Catalog CA-1, "Custom-Made Glassware By Corning." The publication lists items found to be in greatest demand as indicated by repeat orders received during the past thirty years. A detailed description of each piece includes an illustration, code number, size and price. Normally all items will be fabricated to tabulated specification, but, should slight variations be desired, they may be indicated easily. The catalog lists modifications of some of the standard items of Pyrex Brand Laboratory Glassware contained in Catalog LP-34. Apparatus not indexed in either publication will still be made to special order.

The new catalog will be sent free of charge to persons writing on company letterhead to Special Apparatus Section, Laboratory and Pharmaceutical Sales Department, Corning Glass Works, Corning, New York.

A PORTRAIT of Dr. Willard C. Rappleye, who next year celebrates his silver anniversary as Dean of the College of Physicians and Surgeons, was unveiled February 2nd in Columbia University's medical school.

Dr. Grayson Kirk, President of the University, unveiled the portrait, which will be hung in the medical school. The event took place in the lounge of Bard Hall and was followed by a reception.

The work is a gift to the University, commissioned by an anonymous donor and painted by Paul Trebilcock, a New York artist.

Dr. Rappleye, Dean of the Faculty of Medicine, has been University Vice-President in charge of medical affairs since 1949.

He has been Professor of Medical Economics since 1931, the same year he became Dean. From 1933 to 1947 he was Director of the New York Post-Graduate Medical School at Columbia. Also, from 1933 to 1945 he was Dean of Columbia's School of Dental and Oral Surgery.

Dean Rappleye was Commissioner of Hospitals of the City of New York from 1940 to 1942.

A unique "Portfolio of Designs of Hospital Pharmacies," published by Parke, Davis & Company, contains working floor plans of twenty-three active pharmacies serving hospitals with 80 to 1,500 beds.

Believed the first of its kind ever compiled, the portfolio devotes two pages to designs of pharmacies in hospitals with less than 150 beds, four pages to those in hospitals with 150 to 300 beds, and twelve pages to those in hospitals with more than 300 beds.

"The layouts and departmental information on active hospital pharmacies in this portfolio are presented through the courtesy of the hospital pharmacists in charge," Parke, Davis explains. "An endeavor has been made to select those plans presenting a wide variety of layouts and arrangements, grouped for the convenience of the reader, and without classifying the pharmacies in any way.

CONTINUED ON PAGE 52

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NOTES AND QUOTES

"Parke, Davis & Company cannot undertake to prepare individual plans. It is hoped, however, that the plans and data presented may be helpful to our good friends, the Hospital Pharmacists of North America."

Copies of the portfolio are available to interested hospital pharmacists or administrators who send their requests to the Hospital Sales Division, Parke, Davis & Company, Detroit 32, Mich.

PAINFUL inoculation, due to dull or fish-hooked hypodermic needles, may now be avoided by a new, automatic, hypodermic-needle sharpener made by the Physiological Instrument Division of the Franz Manufacturing Company, Inc. of New Haven, Conn. This sharpener automatically restores worn needle points to precision sharpness in a few seconds. No skill is required in its use and it is guaranteed to produce an unexcelled point, based on scientific analysis of requirements.

A light, portable instrument, the sharpener is built for rugged use. It may be permanently mounted on desk or table top, or stored in a drawer. It costs $25.00 and is easy to operate.

A new office model of the Kahn Trigger Cannula that assures a leak-proof cervical seal has been announced by Clay-Adams Company, Inc. The model is especially designed for tubal insufflation (Rubin test) and x-ray diagnoses and can be used with any tubal insufflator. Among the features of the new instrument are two sizes of interchangeable rubber acorns that seal by molding to the shape of the cervix, replaceable Intramedic Polyethylene tip, and a two-notch tenaculum holder that assures parallel alignment of the cannula and tenaculum for a leak-proof cervical seal. All metal parts are non-corrosive. Price of complete outfit is $19.50.

THE country's population, including the Armed Forces overseas, rose to 163,930,000 by the end of 1954. This represents a gain of 2,830,000 during the year, the largest annual increment in our history. For eight consecutive years the increase in our population has exceeded 2½ million annually. The large population growth in 1954 resulted from a record high number of births, an all-time low death rate, and a moderate addition through immigration.

There were about 4,060,000 births during the year, or approximately 90,000 more than the year before, when the previous record high was established. The births in 1954 correspond to a rate of 25.2 per 1,000 population residing in the United States. For nine years now our birth rate has exceeded 24 per 1,000. The boom in births has added 36¾ million babies to the nation's population within the relatively short span of a decade.

The babies born in 1954 set a new mark in their ability to survive the hazards of early life. The infant mortality rate for the year dropped to a new low estimated at 26.7 per 1,000 live births. This is almost 5 per cent under the previous low recorded in 1953, and one-third less than the rate of a decade ago.

Dr. George N. Papanicolaou received the fifth annual Bertner Foundation Award and gave the Bertner Lecture at the ninth annual symposium on Fundamental Cancer Research at The University of Texas M. D. Anderson Hospital and Tumor Institute on March 11th.

The Bertner Award was presented to Dr. Papanicolaou, Professor of Clinical Anatomy at Cornell University College of Medicine for his research contributions in exfoliative cytology that have found such widespread usefulness in cancer control. The medical profession was given a diagnostic tool for the detection of cancer when the disease is still in a curable stage. The tool, the Papanicolaou Smear Technic, has made its most notable contributions in the early diagnosis of cancer of the cervix, body of the uterus, lung and cancer of the urinary tract.

The Award is presented annually for outstanding contribution in the field of cancer research. Previous recipients have been: Dr. Fred Stewart, the late Dr. George Milton Smith, Dr. Charles B. Huggins and Dr. Francis P. Rous. Established in 1950, the award is in honor of the late Dr. E. W. Bertner, first acting Director of M. D. Anderson Hospital and the first President of the Texas Medical Center.

A HANDSOME gift package for physicians entering practice has been announced by Pfizer Laboratories, division of Chas. Pfizer & Co., Inc. Designed to acquaint the newly licensed

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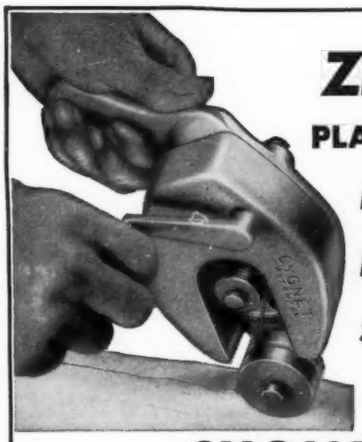

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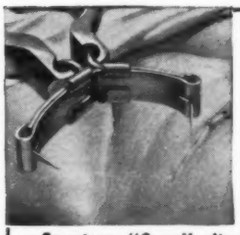

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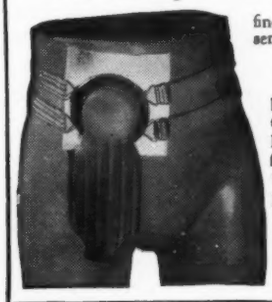

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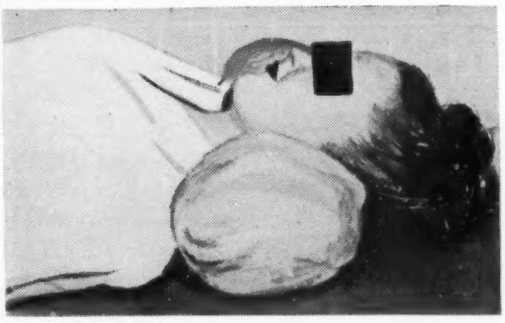

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A new Icterus Index Comparator that gives a simple, rapid, semi-quantitative reading of serum bilirubin level has been announced by Clay-Adams Company, Inc. The unit provides eleven standards of comparison ranging from 1 to 100 units. For convenience and simplicity in conducting the test, the comparator's tubes are designed to fit in the space between the tubes on an Adams Rack for Wintrobe Hematocrit Tubes. The comparator standards are sealed in hematocrit tubes and must always be compared with a serum sample in another similar hematocrit tube. The eleven standards of comparison correspond to 1, 2, 5, 7.5, 10, 15, 20, 25, 50, 75 and 100 units of potassium dicromate per 10,000 parts of water. Complete details of the Icterus Index Comparator are available from your surgical supply dealer, Scientific Supply House, or from Clay-Adams Company, Inc., 141 East 25th Street, New York 10, N. Y.

In two or three seconds you can switch from the normal rate of giving blood to rapid administration under pressure with the new Baxter Plexitron R48 expendable Combination Set. During normal administration the drip chamber is filled with blood to a level just above the filter and the rate of administration is regulated with the control clamp. When the need for pressure arises you merely open the control clamp and pump the flexible drip chamber with a squeeze-release action. As the drip chamber is pumped, it fills quickly with blood so that the ball float rises and seals the intake (drip tube). As a result, when the drip chamber is *squeezed*, blood is forced downward through the set and into the patient's veins. When the drip chamber is *released*, it refills with blood from the bottle and is ready for the next squeeze. The operator can return to normal administration at any time.

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More students entered schools of professional and practical nursing in 1954 than in any year since World War II, according to John H. Hayes, Chairman, Committee on Careers, National League for Nursing.

Schools of professional nursing in the United States and territories admitted 44,930 new students, a 3.7 per cent increase over the 43,327 students admitted in 1953. The 1,141 professional nursing schools reporting admissions to the National League for Nursing represent all state-approved schools offering three-year diplomas or four to five-year degree programs in basic nursing education.

Although returns from schools of practical nursing are incomplete, Mr. Hayes said that reports indicate that the schools will also show a noticeable increase in the number of students admitted in the academic year 1953 to 1954. A tabulation of the first 239 returns gave admission of 10,012 students, while for the academic year 1952 to 1953, 215 schools of practical nursing had reported admissions totaling 8,543 students.

The professional schools graduated 28,539 students; the reporting practical nursing schools, 5,616 students.

Urinary tract infections in pregnancy is the subject of a study to be directed by Dr. Nicholson J. Eastman, Obstetrician-in-Chief at the Johns Hopkins Hospital, Baltimore. Dr. Paul F. MacLeod, Medical Director of Eaton Laboratories, announced a $4,500 grant in support of the project, which will continue for a year. Furadantin® (Eaton), an antibacterial urinary agent, is the first of the nitrofurans developed for systemic use and a determination of its effectiveness in such infections will be included in the study.

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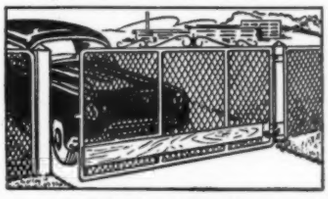

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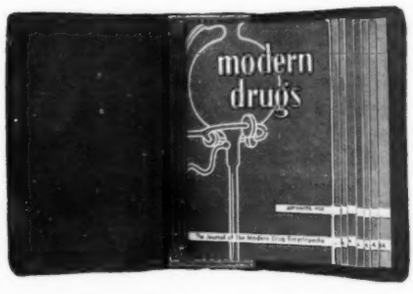

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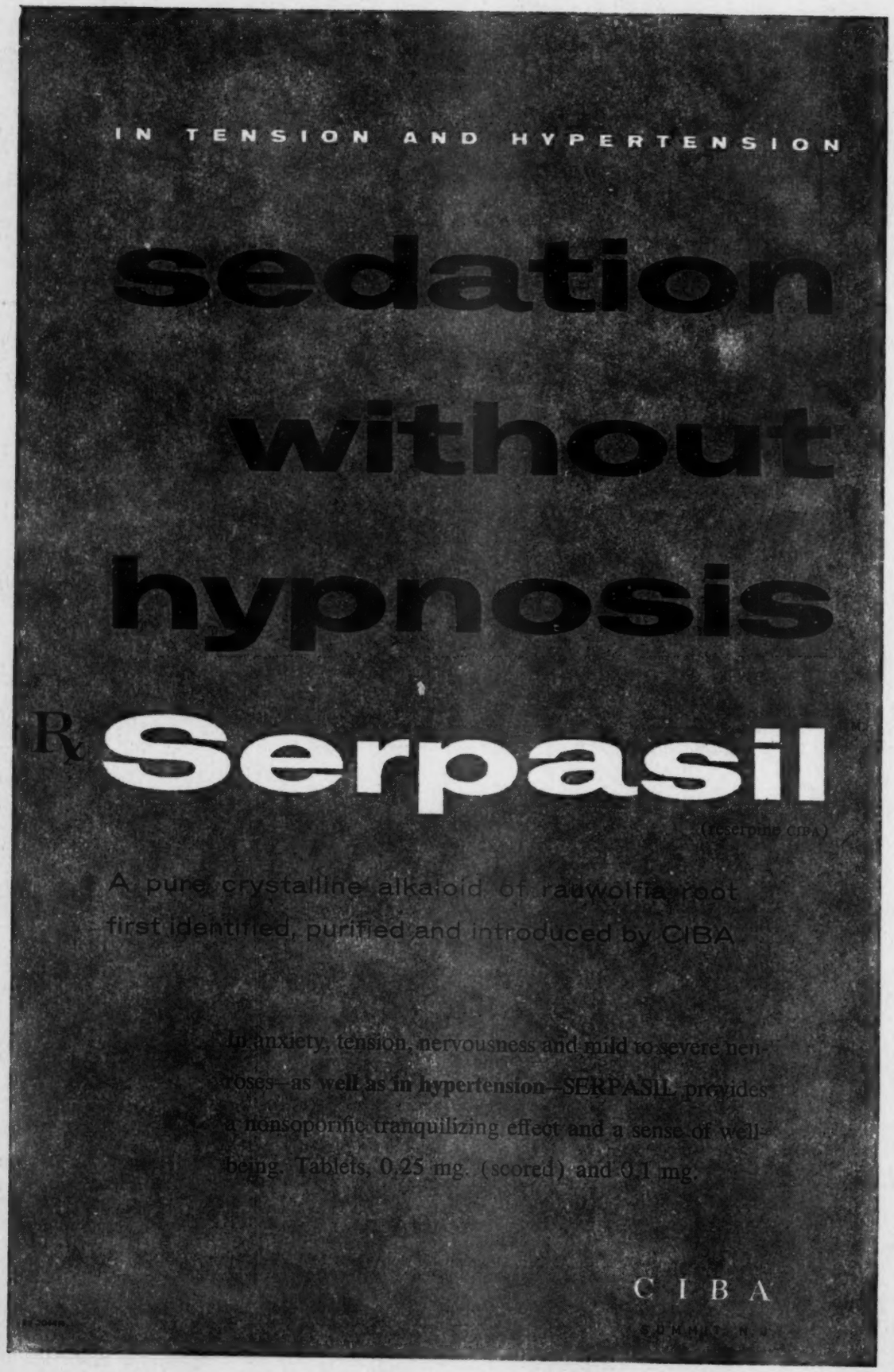
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